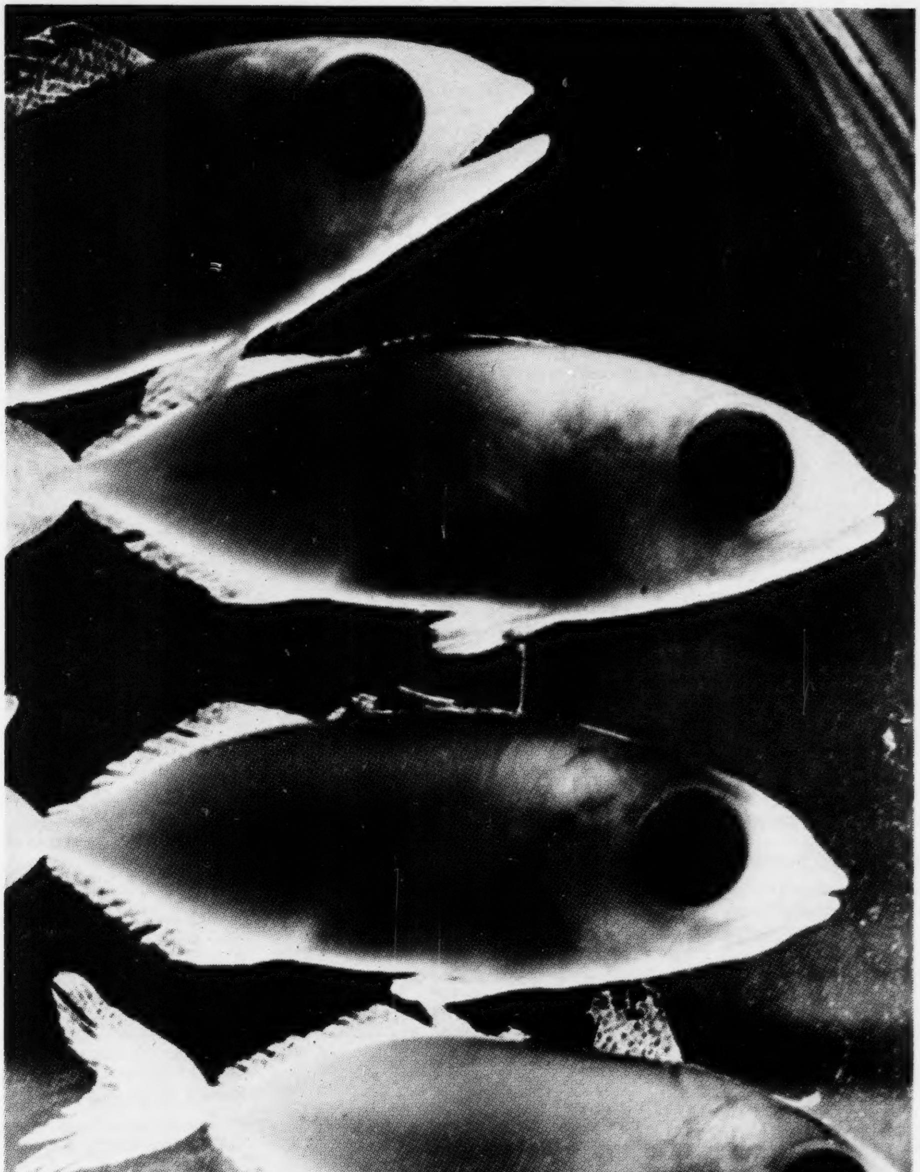
Marine Fisheries REVIEW

March 1979

National Oceanic and Atmospheric Administration • National Marine Fisheries Service



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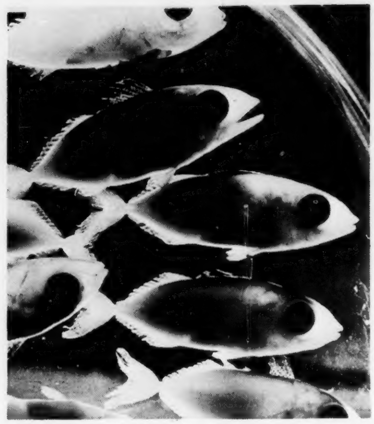

On the cover: Yellowfin tuna larvae. A review of fish egg and larvae survival rates begins on page 1.

U.S. DEPARTMENT OF COMMERCE

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Marine Fisheries Review (USPS 090-890) is published monthly by the Scientific Publications Office, National Marine Fisheries Service, NOAA, Room 450, 1107 N.E. 45th St., Seattle, WA 98105. Single copies and annual subscriptions are sold by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Prices are: Single copy, $1.10; annual subscription, $12.75 (add $3.20 for foreign mailing).

Copies of individual articles, in limited numbers, are available from D822, User Services Branch, Environmental Science Information Center, NOAA, Rockville, MD 20852. Departmental news items are not reprinted.

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A Review of Survival Rates of Fish Eggs and Larvae in Relation to Impact Assessments

MICHAEL D. DAHLBERG

Introduction

Pursuant to promulgation of the Federal Water Pollution Control Act Amendments of 1972, Section 316b, electric generating stations are required to demonstrate that cooling water intake structures reflect the best technology available for minimizing adverse environmental impact. The primary types of impact are impingement of fish on the intake screens and entrainment of smaller fish and eggs into the cooling system. The size of the intake screen mesh, usually ⅜ inch, and size of fish determine whether the fish are entrained or impinged. The impingement problem was reviewed by Hanson et al. (1977). The few published studies on entrainment of fish show that millions of larvae are sometimes entrained daily by a plant during the period of peak abundance (Edsall, 1975). Impact of entrainment or other perturbations may be assessed by translation of egg and larval losses to the potential number of adults they represent in the absence of entrainment. This is compared with a reference such as stock size or commercial catch. Implementation of models requires information on natural survival rates of the species of concern, or at a minimum, what survival rates may be expected among the various groups of fishes.

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ABSTRACT—Enormous fecundities of fishes are balanced by high egg and larval mortalities resulting from natural interacting environmental stresses. Survival rates generally increased inconsistently with age of eggs and larvae. Few published studies provided the data needed to compare relative mortality among the three major developmental stages. Mortality was greatest during the egg stage in the walleye and striped bass, but during the postlarval stage in some marine species. Wide ranges of egg survival for Atlantic herring, northern pike, rainbow smelt, and walleye depend on whether egg production is based on fecundity or field counts, and whether survival is measured to a stage of drifting larvae or late eggs.

Among freshwater species, hatching success was low in unprotected eggs and high in species which exhibit parental care, construct nests, but do not exhibit parental care, have special protective mechanisms (yellow perch), and apparently in species which deposit eggs in vegetation. Among anadromous species, egg survival in striped bass was particularly low in comparison to that in salmon. In the sea, hatching success of demersal eggs was much higher than in pelagic eggs. Survival of yolk-sac larvae was generally higher in marine and freshwater species than in anadromous species. Survival of postlarvae was highest in freshwater species in relation to high daily survival rates and short developmental periods.

The occurrence of brief critical periods of high mortality was generally not supported when data were corrected for larval extrusion. The potential for high mortality to be offset by compensatory mechanisms is supported by literature. A direct relationship of survival rates and development time suggested that high mortality rates were an expected mechanism for regulation of populations having short developmental periods. The availability and applicability of survival data to modeling of impact is assessed. Many environmental factors should be considered when extrapolating survival data from one site to another.

This paper represents a compilation of available fish egg and larval natural survival rates and discusses problems associated with interpretation and use of survival data, major sources of mortality, survival rates associated with various reproductive strategies, and the critical period concept. Effects of human perturbations and fish culture on survival rates are not considered.

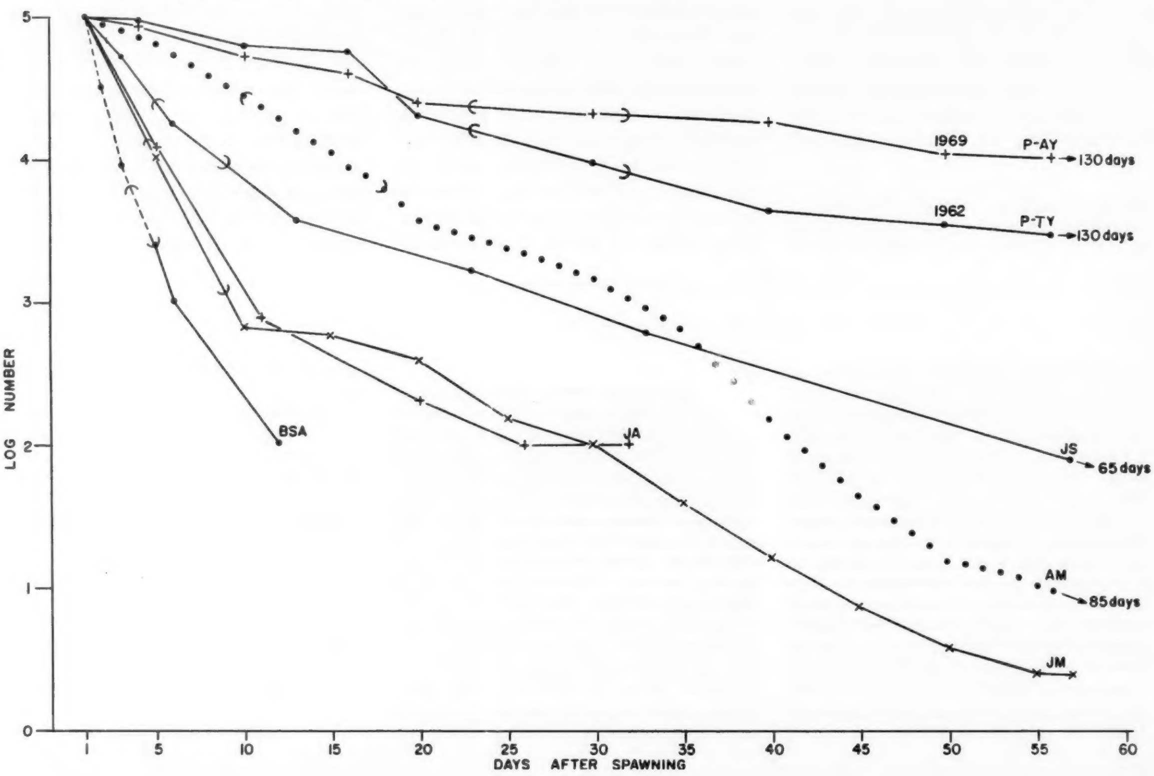
Interpretation of Survival Data

Since survival data are of little value for modeling unless they are available for each of the developmental stages (Table 1), it was necessary to construct survival curves and designate times of transition to subsequent stages (Fig. 1-4) when adequate data were available. Stages are classified as eggs, yolk-sac larvae (from hatching to complete absorption of yolk-sac), and postlarvae (from yolk-sac absorption to demersal or fully developed juvenile).The survival curves are also necessary to examine the critical period concept, which is dependent on differences of slope within a curve rather than absolute rates of mortality (Pearcy, 1962). Representative survival data are presented, either by selection of data which appears to be typical of different years of study or by averaging data for more than 1 year as described in the footnotes. However, it is not possible at this time to quantitatively account for all errors which may result from bias in sampling methodology.

Complete data on postlarvae are available for relatively few species because avoidance of plankton nets increases with size of larvae. It was neccessary to assume that postlarval survival rate was constant in order to complete the postlarval survival curves for Pacific sardine[1] and yellow perch, as described in Table 1. This avoidance problem may be resolved by collection of postlarvae or juveniles with trawls, as in studies of walleye (Forney, 1976), winter founder (Pearcy 1962), and Atlantic herring (Graham et al., 1972), or with trap nets, as in northern pike studies (Forney, 1968).

[1]Scientific names follow Bailey et al. (1970) except foreign names as listed in Table 4.

Figure 1.—Survival curves for eggs and larvae of plaice during abnormal (P-AY) and typical (P-TY) years. Atlantic mackerel (AM), Japanese sardine (JS), jack mackerel (JM), Japanese anchovy (JA), and Black Sea anchovy (BSA). Incomplete segments are indicated by arrows. Yolk-sac stages indicated by parenthesis. See Tables 1 and 2 for sources.



Determination of survival of yolk-sac larvae generally required interpolation between the egg and fully vulnerable yolk-sac stages. This approach is necessary because the smallest larvae are generally extruded through nets in the sea and are not fully planktonic in freshwater. This approach results in a constant survival rate for smaller larvae instead of a more probable tendency for survival to increase during this period.

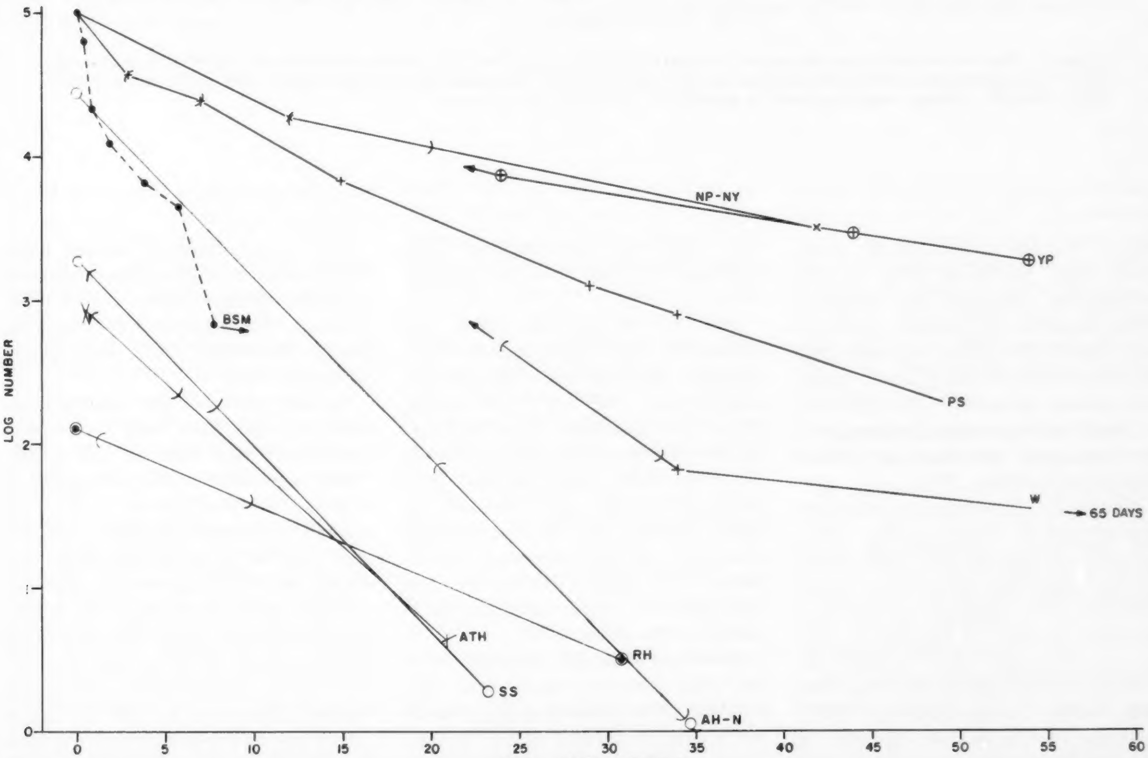
Egg production was indicated by numbers of 5-day-old eggs in plaice (Bannister et al., 1974) and 1.8-day-old eggs in jack mackerel (Farris, 1961). Actual egg production was estimated by extrapolation to the spawning date, assuming a constant survival rate among the early egg stages.

The use of age-related fecundity data to calculate egg production is a possible source of error in the survival data for northern pike (Forney, 1968), walleye (Forney, 1976), yellow perch (Clady, 1976) and Atlantic herring off Norway (Dragesund and Nakken, 1973). This may result in high estimates of egg production if fertilization is not complete, egg extrusion is incomplete as in salmon (Johnson, 1965), or there are non-spawning adults as in walleye (Forney, 1976) and salmon (Johnson, 1965). Clady (1975) indicated that the ratio of eggs deposited (based on field counts) and potential egg deposition (based on fecundity) was low (15-34 percent) in a smallmouth bass population. However, this was possibly a result of egg predation by red water mites before the eggs were sampled. Comparisons of egg production based on fecundity, and water body sampling yielded differences varying by a factor of 2.7 in striped bass (Polgar, 1977) and 3-34 in Clyde herring (Saville et al., 1974). However, these discrepancies were thought to be a result of inadequate egg sampling rather than incomplete egg production.

Major Factors Which Influence Mortality Rates

The applicability of data from one region for another will depend on how similar the environmental conditions are during the developmental periods. A number of the major factors which should be considered are discussed

Figure 2.—Survival curves for eggs and larvae of northern pike (NP), yellow perch (YP), walleye (W), Pacific sardine (PS), Black Sea mackerel (BSM), Atlantic herring in Norway (AH-N), round herring (RH), Atlantic thread herring (ATH), and scaled sardine (SS). Yolk-sac stages indicated by parenthesis. See Tables 1 and 2 for sources.



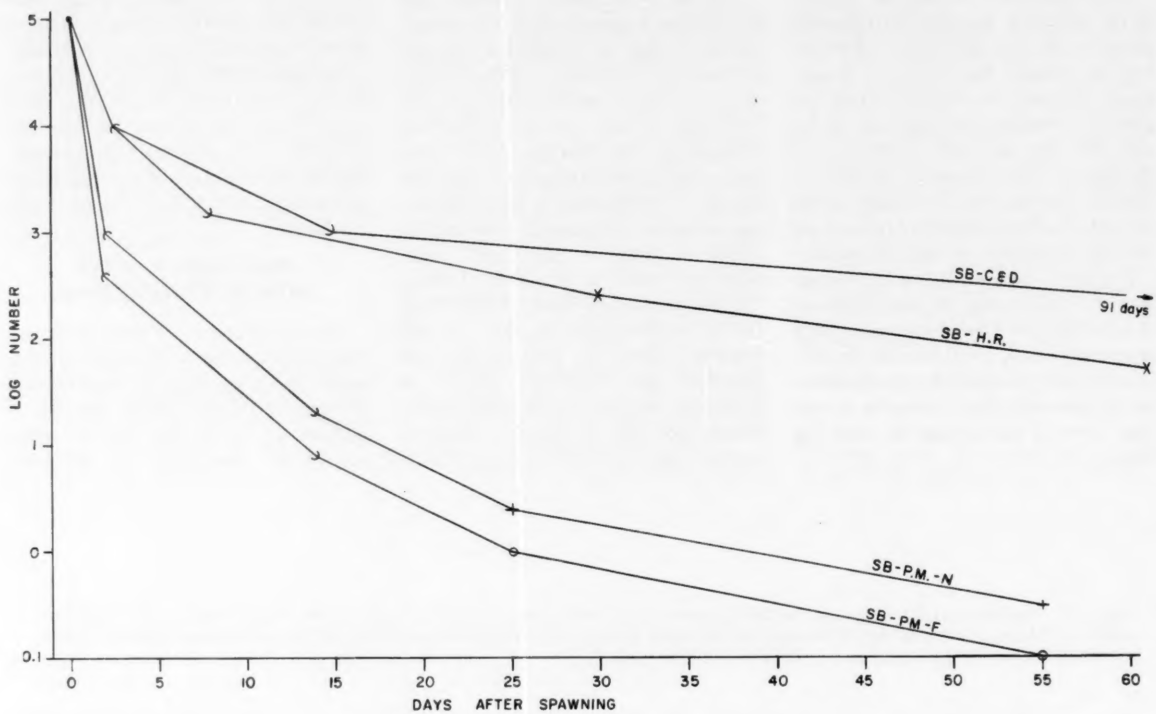


Figure 3.—Survival curves for eggs and larvae of striped bass in Potomac River based entirely on net samples (SB-PM-N), in Potomac River with egg densities based on fecundity-at-age data (SB-PM-F), in Chesapeake and Delaware Canal (SB-C & D), and in Hudson River (SB-HR). Yolk-sac stages indicated by parenthesis. See Table 1 for sources.

below. Further quantification would lend more predictive value to this information. However, this would be rather academic for predictive purposes since extent of mortality is a function of intensity as well as type of perturbation. Quantitative estimates of the magnitude of mortality due to some factors such as predation and starvation are almost totally lacking (May, 1974).

Substrate characteristics influenced egg survival in salmon (Larkin, 1977), brook trout (Hausle and Coble, 1976), walleye (Johnson, 1961), and herring (Galkina, 1971). Siltation was a source of mortality in eggs of smallmouth bass (Latta, 1975), lake trout (Youngs and Oglesby, 1972), salmon (McNeil, 1966) and Pacific herring (Galkina, 1971). Survival of Pacific herring eggs in subtidal water was about 100 percent when eggs were deposited on high vegetation and free from silt (Galkina, 1971).

Low flow or low water levels were detrimental to survival of eggs of salmon (Warner, 1963; McNeil, 1966), rainbow smelt (Rupp, 1965) and Pacific herring (Soin, 1971), and larvae of northern pike (Hassler, 1970) and striped bass (Stevens, 1977). Mortality often resulted from stranding of the eggs. Mortality of Pacific herring eggs from desiccation increased from 30 to 100 percent from the lower to the upper intertidal zone, and total mortality was 5 percent or less in subtidal areas (Soin, 1971).

Reduction of oxygen to a critical level can cause mortality, e.g., salmon eggs (McNeil, 1966), brook trout eggs (Hausle and Coble, 1976), carp eggs (Nikolskii, 1969), and Baltic cod larvae (Grauman, 1973). Lethal dissolved oxygen levels were caused by high egg concentrations in Atlantic herring (Jones and Hall, 1974), Pacific herring (Hempel, 1971), rainbow smelt (McKenzie, 1947), and salmon (Johnson, 1965).

Adverse effects of low water temperature on eggs have been shown with smallmouth bass (Kramer and Smith, 1962), rainbow smelt (Rothschild, 1961), and northern pike (Hassler, 1970). Low water temperatures apparently reduced the rate of larval development and caused prolonged exposure to predation in plaice (Bannister et al., 1974), Pacific sardine (Murphy, 1961), Atlantic herring (Graham et al., 1972), northern anchovy (O'Connell and Raymond, 1970), and walleye (Busch et al., 1975). Colton (1959) reported mass mortality of marine fish larvae due to natural warming. A

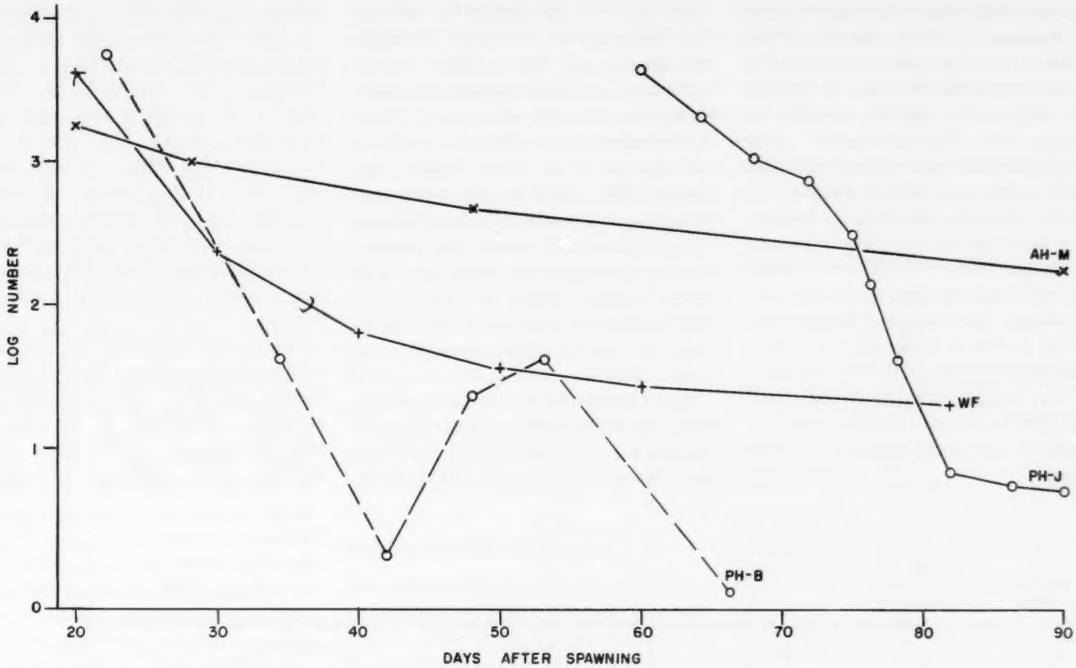


Figure 4.—Partial survival curves for larvae of winter flounder (WF), Atlantic herring off Maine (AH-M), Pacific herring off Japan (PH-J), and Pacific herring off British Columbia (PH-B). Approximate days after spawning are indicated. See Tables 1 and 2 for sources.

rapid rise in water temperature adversely affected embryonic and larval survival in herring (Rannak, 1971).

Storms and wave action caused mortality of herring larvae (Wiborg, 1976) and cod eggs (Rollefsen, 1930). Wave action caused stranding of 1 percent of the yellow perch eggs in a lake (Clady, 1976) and along with low temperature was responsible for failure of largemouth bass nests (Kramer and Smith, 1962).

Egg loss from nonfertilization is generally minimal and has been reported as about 1 percent in salmonids (Warner, 1963) and 0.2-0.4 percent in Baltic herring (Rannak, 1971). Egg loss from predation has been reported in many species, including Atlantic herring (Dragesund and Nakken, 1973), Pacific herring (Soin, 1971), smallmouth bass (Latta, 1975), and rainbow smelt (Rothschild, 1961). Predation and cannibalism were significant sources of larval mortality in Black Sea anchovy (Dekhnik et al., 1970), Black Sea mackerel (Dekhnik, 1964), Japanese anchovy (Nakai et al., 1955), Pacific sardine (Murphy, 1961), northern anchovy (O'Connell and Raymond, 1970), winter flounder (Pearcy, 1962), walleye (Forney, 1976), yellow perch (Tarby, 1974), northern pike (Forney, 1968), pink salmon (Johnson, 1965), and sockeye salmon (Hartman et al., 1962). Occasional high rates of predation on eggs and larvae of roach, rainbow trout, and other freshwater species were noted by Paling (1971).

The hypothesis that lack of food causes larval mortality (Hjort, 1914) has been supported by studies of Atlantic mackerel (Sette, 1943), plaice (Bannister et al., 1974), Japanese sardine (Nakai and Hattori, 1962), Atlantic herring (Graham et al., 1972), pilchard (Karlovac, 1967), and Japanese anchovy (Nakai et al., 1955). Dekhnik et al. (1970) noted that postlarvae survive 10-18 days without food and concluded that "...the food factor cannot be considered a cause of the mortality of fish larvae in the Black Sea." However, inadequate food increases vulnerability to other stresses and its effect on survival is mainly indirect (Nikolskii, 1969).

Relationship of Survival Rates to Reproductive Strategies

In addition to specific environmental factors cited above, it is possible to make some generalizations regarding the survival rates of fish eggs and larvae in relation to different reproductive strategies and habitats.

Survival of Fish Eggs

Hatching success of eggs is often low in freshwater species which do not guard the demersal eggs. As little as 3 percent survival from egg to migrant larvae has

been reported for the white sucker (Scott and Crossman, 1973). Forney (1976) noted less than 1 percent walleye survival through the swim-up stage in Oneida Lake, with most of the loss probably in the egg stage. Walleye survival from recently spawned eggs to a prehatching "eyed" stage was 2.4-25 percent on various natural substrates (Johnson, 1961). High egg mortality also occurs in the rainbow smelt: Rothschild (1961) reported 24 percent egg survival (to 1-15 days before hatching) and 0.5 percent survival to the drifting yolk-sac stage; McKenzie (1947) found that the hatching rate was usually 0.8-1.8 percent; and Rupp (1965) reported a mean hatch of 1.1 percent in lakeshore spawners of this species.

Egg survival was generally high in freshwater species exhibiting parental care (Breder and Rosen, 1966) and in freshwater and anadromous salmonids which cover the eggs with gravel (Table 3). Parental care was a factor in the 49-94 percent survival of white crappie eggs (Siefert, 1968), 26-33 percent survival to emergence in smallmouth bass (Clady, 1975; Latta, 1975), and 94 percent survival of smallmouth bass eggs in a stream (Pflieger, 1966). However, only 44-55 percent of smallmouth bass nests produced fry in large natural lakes (Latta, 1975).

High egg survival has been reported in three freshwater species which spawn in vegetation: 60-95 percent for northern pike (Franklin and Smith, 1963), 80-94 percent at high oxygen concentrations for carp (Nikolskii, 1969), and 34-90 percent for carp-bream (Nikolskii, 1969). Forney (1968) reported 77 percent viability of northern pike eggs in a regulated marsh but found that recruitment to pelagic yolk-sac larvae was only 16-19 percent. Protection afforded by the unique egg mass envelopes contributes to high survival of yellow perch eggs: Clady (1975) observed that viability was generally over 95 percent.

Survival of unguarded demersal eggs of three marine species (Atlantic herring, Pacific herring, and capelin) was generally considered to be over 90 percent (Baxter, 1971; Soin, 1971; Rannak, 1971; Gjøsaeter and Saetre,

Table 1.—Survival rates of eggs and larvae of marine, freshwater, and anadromous fishes. Footnotes are cross-referenced to Figures 1-5.

	Eggs			Yolk sac larvae			Postlarvae			Total		
Fishes	Survival	Days	Survival per day	Survival	Days	Survival per day	Survival	Days	Survival per day	Survival	Days	Survival per day
Marine												
Atlantic herring[1]	0.030	21	0.846	0.175	14	0.884	0.050000	90	0.967	0.000263	125	0.936
Atlantic mackerel[2]	0.300	9	0.875	0.200	8	0.818	0.000067	60	0.852	0.000004	77	0.851
Atlantic thread herring[3]	0.660	0.8	0.595	0.400	4.9	0.830						
Black sea anchovy[4]	0.060	2.5	0.325	0.383	1.5	0.527						
Jack mackerel[5]	0.132	3.5	0.560	0.100	4.5	0.600	0.002182	49	0.885	0.000024	57	0.830
Japanese sardine[6]	0.270	4	0.721	0.333	4	0.760	0.003333	62	0.913	0.000300	70	0.893
Pacific sardine[7]	0.360	3	0.712	0.667	4	0.904	0.008333	43	0.896	0.002000	50	0.883
Plaice[8]	0.118	22	0.907	0.678	9	0.958	0.000125	99	0.914	0.000010	130	0.915
Round herring[9]	0.380	2	0.616	0.250	8	0.841						
Scaled sardine[10]	0.120	0.8	0.071	0.106	7.5	0.742						
Freshwater												
Northern pike[11]	0.180	13	0.880	0.572	8	0.931	0.291262	22	0.945	0.030000	43	0.922
Walleye[12]	0.005	24	0.800	0.132	9	0.800	0.333333	31	0.965	0.000060	64	0.859
Yellow perch[13]							0.259740	30	0.956	0.020000	55	0.931
Anadromous												
Striped bass[14]	0.009	2	0.095		12	0.726	0.014000	41	0.901	0.000003	55	0.793
Striped bass[15]	0.003	2	0.055	0.021	12	0.726	0.014000	41	0.901	0.000001	55	0.778
Striped bass[16]	0.100	2.5	0.398	0.100	12.5	0.832	0.100000	75	0.970	0.001000	90	0.926
Striped bass[17]	0.100	2.25	0.360	0.150	6	0.728	0.030000	52	0.935	0.000450	60	0.879

[1]Dragesund and Nakken (1973). Means of egg survival (0.01-0.05) and yolk-sac larva survival (0.05-0.30). Egg survival based on fecundity-at-age data. (Fig. 2). Postlarva data from Cushing (1974). Average values for 6-year study, limited to first 90 days. (Fig. 4)

[2]Sette (1943). Planktonic survival was 1×10^{-6} to 1×10^{-5}, but 4×10^{-6} in his Figure 17. Apparent net avoidance in older larvae. (Fig. 1)

[3]Houde (1977b). Means of survival to 5.5 mm yolk-sac larvae and 15.5 mm early postlarvae. (Fig. 2)

[4]Dekhnik (1963), Nikolskii (1969). Egg survival also given as 58 percent (Dekhnik, 1960) and 19-40 percent (Pavlovskaia, 1955). (Fig. 1)

[5]Farris (1961). Means of data for 3 years. Survival for first month was approximately 0.1 percent all 3 years. Eight day period of yolk nutrition (Farris, 1960). (Fig. 1)

[6]Nakai and Hattori (1962, Table 6). Means of data for 3 years. (Fig. 1)

[7]Lenarz (1972) for abundance by length and Ahlstrom (1954) for age-length relationship. Samples collected at night and corrected for extrusion (Lenarz, 1972). Egg survival (0.36) from Smith (1973). Four-day yolk-sac larva period (Ahlstrom, 1954). Daily survival rate for days 30-35 assumed to be constant through day 50. (Fig. 2)

[8]Bannister et al. (1974). Data for typical year (1962). Yolk-sac larva period follows Ryland (1966). (Fig. 1)

[9]Houde (1977a). Means of survival to 5.5-mm yolk-sac larvae and 15.5-mm early postlarvae. (Fig. 2)

[10]Houde (1977c). Means of survival to 5.5-mm prolarvae and 15.5-mm early postlarvae. (Fig. 2)

[11]Forney (1968). Means of data for 2 years. Assume transformation to juvenile at 35 mm and 43 days after spawning (Franklin and Smith, 1963). Actual egg survival was between the observed 77 percent viability and 18 percent survival to pelagic yolk-sac larvae. (Fig. 2)

[12]Forney (1976). Mean values for 3 years in which cohorts which were not augmented with yolk-sac larvae. Survivorship of yolk-sac larvae (13.2 percent) estimated from relative numbers of 1- to 3-day-old larvae and 10-day-old larvae by assuming that differences in numbers of 10-day-old larvae in augmented and unstocked cohorts resulted from stocking. Egg production based on fecundity. Trawled juvenile data used to complete the postlarvae survival segment. (Fig. 2)

[13]Noble (1975). Survival values for days 25 to 45 in 3 years, assumed to be constant to demersal age (55 days). Survival and duration of earlier stages from Clady (1975). (Fig. 2)

[14]Polgar (1977, Table 2). Assumed exponential age distribution. Net samples only, through post-finfold (late postlarva) stage. (Fig. 3)

[15]Polgar (1977). As above, but with egg production based on fecundity-at-age data. (Fig. 3)

[16]Portner (1975). Assumed 0.100 survival for each stage. (Fig. 3)

[17]LMS (1975), Swartzman et al. (1977). Net samples only, through juvenile I (late postlarva) stage. (Fig. 3)

1974). Lower survival from spawning on less suitable substrates or from dense packing of eggs has been reported, but this is probably of little consequence in comparison to predation on eggs (Hempel, 1971). Dragesund and Nakken (1973) concluded that egg loss from predation was 15-40 percent, and mortality from hatching to recruitment into the plankton was 83-95 percent in one herring population. An assumed 10 percent hatch of demersal winter flounder eggs (Hess et al., 1975) has not been verified.

Data in Table 1 indicate that survival of pelagic eggs in the sea was relatively low (6-66 percent, mean 26 percent) although Murphy (1977) concluded that demersal eggs were more vulnerable to predation. However, survival of Black Sea anchovy eggs has also been reported as 58 percent (Dekhnik, 1960) and 19-40 percent (Pavlovskaia, 1955). Survival of pelagic Japanese anchovy eggs was 70 percent (Hayasi, 1967). Survival of pelagic sole eggs was 0.05 percent and 4.35 percent at two locations off England (Riley, 1974). Survival of pelagic cunner eggs was estimated as 5 percent by Williams et al. (1973). Survival of pelagic Baltic (Atlantic) cod eggs varied from 1 to 21 percent in relation to dissolved oxygen, buoyancy (resulting from salinity) and egg quality (based on size and fat content) (Grauman, 1973). Survival of pelagic Argentinean anchovy eggs was 7-13 percent (Ciechomski and Capezzani, 1973). There are additional observations on viability of pelagic eggs, which probably exceed actual survival rates, e.g., viability of pelagic pilchard eggs was 50 percent off England and 48-87 percent in other studies (Southward and Demir, 1974). Very low survival (0.3-10 percent) was also reported for the semibuoyant eggs of anadromous striped bass (Table 1).

Survival of Yolk-Sac Larvae

Survival of yolk-sac larvae ranged from 2.3 percent (winter flounder) to 68 percent (plaice) in marine species, 13 to 57 percent in two freshwater species, and 2.1 to 15.0 percent in striped bass (Tables 1-3). Daily survival rates were 53-96 percent, 80-93 percent, and 73-83 percent, respectively. Survival of yolk-sac larvae of Danubian shad was less than 10 percent (Dekhnik et al., 1970). Thus, there are no obvious differences in survival rates among the groups with the possible exception of low survival in the anadromous species.

Survival of Postlarvae

Postlarval survival (Table 1) was considerably higher in the three

Table 2.—Survival rates of fish larvae and various larva and egg combinations not shown in Tables 1 and 3. Footnotes cross-referenced to Figures 1-5.

Species	Stage	Survival	Days	Survival per day
Winter flounder[1]	Yolk-sac larvae	0.023	17	0.800
	Postlarvae	0.319	28	0.960
Pacific herring[2]	10-15 mm postlarvae	0.120	14	0.860
	15-18 mm postlarvae	0.017	8	0.601
	18-28 mm postlarvae	0.500	19	0.964
	10-28 mm postlarvae	0.0009	40	0.839
Pacific herring[3]	Postlarvae	0.0005	20	0.684
	Postlarvae	0.025	11	0.715
Pilchard[4]	2-20 mm larvae	0.004		
Northern anchovy[5]	3-16 mm larvae	0.007		
Chub mackerel[6]	Eggs and larvae	0.005	23	0.721
Japanese anchovy[7]	Eggs and larvae	0.0009	31	0.799
Black sea mackerel[8]	Eggs	0.207	1.1	0.239
	Yolk-sac larvae	0.056	6	0.618
Smallmouth bass[9]	Eggs to fry emergence	0.286	10	0.882
Smallmouth bass[10]	Eggs to fry emergence	0.941	10	0.994

[1]Pearcy (1962). Data excludes 2.3-3.5 mm larvae. Translocation was minor component of total losses. Survival curve extrapolated to complete transformation age in Figure 4.
[2]Iizuka (1966). Data for postlarvae in 1959, representing three distinct survival slopes. Complete recruitment at 60 days after spawning. (Fig. 4)
[3]Stevenson (1962). Bimodal curve represents two broods of larvae. (Fig. 4).
[4]Karlovac (1967). 2-20 mm larvae (Fig. 5).
[5]Lenarz (1972). 3-16 mm larvae. Night samples corrected for losses through 0.55-mm mesh. (Fig. 5).
[6]Watanabe (1970). Spawning to day 23. Also called Japanese common mackerel.
[7]Nakai et al. (1955). Survival from spawning to day 31. Mean of 3 years. (Fig. 1).
[8]Dekhnik (1964). From his table 3. (Fig. 2).
[9]Clady (1975). Data for 3 years. Ten-day duration from Allan and Romero (1975). Survival also reported as 27.6 percent (Latta, 1963).
[10]Pflieger (1966). Stream population. Duration from Allen and Romero (1975).

Table 3.—Survival rates of salmonids from egg to hatching and emergence in nature.

Species	Hatching	Egg to emergence
Atlantic salmon[1]	0.93	0.92
Brook trout	[2]0.80-0.93, [3]0.84	[3]0.59, [4]0.79
Brown trout rainbow trout and chinook salmon[5]	0.71-0.97	0.91
Brown trout	[6]0.89, [7]0.98	
Chum salmon[8]	Over 0.80	0.01-0.25
Coho salmon	[9]0.35-0.85 [10]0.85	[11]0.26-0.54, [12]0.14-0.54
Cutthroat trout[13]	0.25-0.40	
Lake whitefish[14]		Less than 0.13
Pink salmon	Over [15]0.80	[16]0.03-0.21 [17]0.01-0.25
Rainbow trout		[18]0.42-0.92
Sockeye	[19]0-0.79	[20]0.20, [21]0.085
Steelhead	[22]0.86	[23]0.40

[1]Warner (1963). Survival to late eyed stage and emergence.
[2]Shetter (1961). Typical range.
[3]Hausle and Coble (1976).
[4]Brasch (1949). Upwelling favorable to survival.
[5]Hobbs (1940). New Zealand.
[6]Allen (1951) and Braum (1971).
[7]Kramer and Smith (1965).
[8]McNeil (1966). Typical emergence values.
[9]Cloern (1976). Typical range, but 0-0.014 in Wisconsin.
[10]Briggs (1953).
[11]Moring and Lantz (1975).
[12]Koski (1966).
[13]Ball and Cope (1961).
[14]Van Oosten (1956).
[15]McNeil (1966).
[16]Hanavan and Skud (1954). Tidal waters
[17]McNeil (1966). Typical values
[18]Bjorn (1966). Planted eggs.
[19]Krogius (1951).
[20]Johnson (1965). Survival to entry into nursery ground
[21]Hartman et al. (1962). Survival to fry outmigration.
[22]Briggs (1953).
[23]Coble (1961).

Table 4.—List of common and scientific names of foreign fishes cited in this paper.

Common name	Scientific name
Argentinean anchovy	*Engraulis anchoita*
Black sea anchovy	*Engraulis encrasicholus*
Black sea mackerel	*Trachurus mediterraneus*
Carp-bream	*Abramis brama*
Danubian shad	*Alosa alosa*
Japanese anchovy	*Engraulis japonica*
Japanese sardine	*Sardinops melanosticta*
Pilchard	*Sardina pilchardus*
Roach	*Rutilus rutilus*
Sole	*Solea solea*

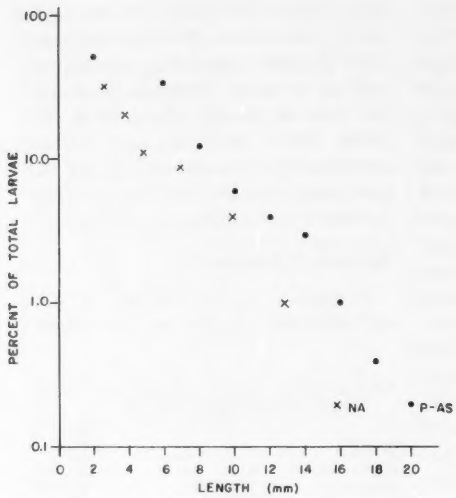


Figure 5.—Partial larval survival curves of Adriatic Sea pilchard (P-AS) and northern anchovy (NA) in terms of percent of total larvae VS length. See Table 2 for sources.

freshwater species (26-33 percent) than in the 10 examples of marine species (0.01-31.9 percent, mean 4.09 percent). This may be attributable to higher daily survival rates and shorter postlarval periods (22-31 days). An intermediate rate of survival is apparent for the 41-75 day postlarval periods in the striped bass.

Observations on Possible Critical Periods

Enormous fecundities of fishes are balanced by high mortality rates. The occurrence of most mortality during a short period in early development is the critical period concept. Total losses are undoubtedly highest during egg or yolk-sac larva stages (Farris, 1960, Dekhnik et al., 1970). If a critical period can be identified, then it is likely that the consequences of human perturbations would be much greater if they occurred after the critical period rather than before.

Critical period may also be viewed in terms of relative survival rates among the developmental stages. Data in Tables 1 and 2 indicate that mortality is greatest in the postlarval stages of the marine species and also in the Hudson River striped bass. Therefore, the environmental conditions existing during the relatively long postlarval periods may be more critical to the determination of year-class strength than the egg and yolk-sac larva environments.

Critical periods have been postulated for many species. Larval survival curves, presented as percent of larvae VS length, for Pacific hake, jack mackerel, Pacific sardine, and northern anchovy (Lenarz, 1973) revealed some evidence for early critical periods, but there was also some degree of extrusion through the 0.55-mm mesh net. Survival curves of pacific sardine (Fig. 2) and northern anchovy larvae (Fig. 5) did not provide any evidence of a critical period when densities were corrected for loss of small larvae through the mesh (Lenarz, 1972).

Survival curves of herring larvae do not follow a consistent pattern (Fig. 2, 4). Mortality rates of Norwegian herring larvae were estimated at 94 percent in 6 days (10-12 mm) (Dragesund and Nakken, 1971, May 1974) and 70-95 percent in 14 days (9-13 mm) (Dragesund and Nakken, 1973). The delay of a high mortality period (98 percent in 8 days) to a size range of 15-18 mm in Pacific herring postlarvae in Japanese waters (Iizuka, 1966) may be attributable to their retention in a bay. The relatively constant survival rate of yolk-sac and postlarval Atlantic herring in the Gulf of Maine (Graham et al., 1972 as modified by Cushing, 1974) suggests that observation of high mortality in other populations of herring may result from offshore drift or errors caused by net avoidance. Offshore drift as a major cause of death was postulated for Pacific herring in British Columbia (Stevenson, 1962) although the extent of mortality at sea was not determined.

Observations representing catastrophic mortality may be confused with critical periods. Catastrophic mortality in the early larval stages of herring was documented by Soleim (1942). Marr (1956) and May (1974) suggested that the net in this study was contaminated with herring larvae of previous hauls. Wiborg (1976) and Nikolskii (1969) cited evidence that such mass mortalities result from storms.

The occurrence of a critical period in Adriatic pilchard (Karlovac, 1967; May, 1974) is not strongly supported by Karlovac's data. Samples were collected at monthly intervals during the spawning seasons, and larval densities were tabulated by size. A plot of larval numbers as percent of total larvae VS lengths (Fig. 5) following the procedure of Lenarz (1972), does not provide any evidence of a critical period. However, no correction for variation in growth rate was made.

Data on striped bass of the Potomac River, Chesapeake and Delaware Canal, and Hudson River (Table 1, Fig. 3) reveal very high mortality of eggs (90-99.7 percent). Highest egg mortality of Potomac River striped bass is apparent when egg production is based on fecundity-at-age data. The marked differences in the striped bass survival curves for the three study areas are influenced by the use of hypothetical survival rates for the Chesapeake and

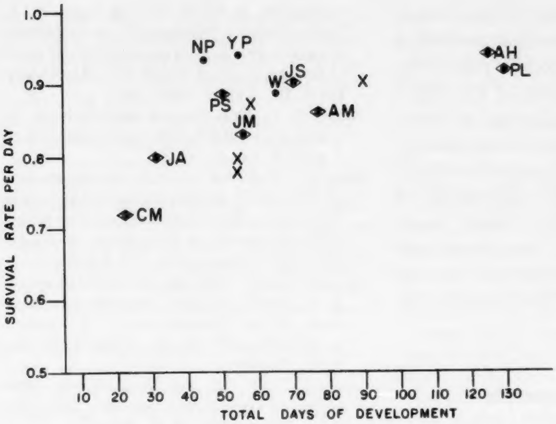


Figure 6.—Relationship of daily survival rates and lengths of developmental period in striped bass (X), chub mackerel (CM), Japanese anchovy (JA), northern pike (NP), Pacific sardine (PS), yellow perch (YP), jack mackerel (JM), walleye (W), Japanese sardine (JS), Atlantic mackerel (AM), plaice (PL), and Atlantic herring (AH). Diamond figure indicates marine species. See Tables 1 and 2 for sources.

Delaware Canal population, and by differences in sampling and/or data interpretations, and therefore do not provide strong evidence for a critical period.

Maintenance of stock size depends largely on egg production and rate of survival through egg and larval stages. It follows that species having short periods of egg and larval development will exhibit higher daily mortality rates which may be interpreted as critical periods. To investigate the relationship of daily egg and larval survival rates with total time of egg and larval development, these data (Tables 1, 2) were plotted for species represented by relatively complete survival data (Fig. 6). Daily survival rates ranged from 72 percent in chub mackerel to 94 percent in Atlantic herring and a general correlation is apparent. However, the low survival rates of chub mackerel and Japanese anchovy are strongly influenced by the absence of larger larvae. A trend of increasing survival with time of development is apparent with the remaining marine species. Higher daily survival rates apparently represent a compensatory mechanism, functioning to maintain egg and larval populations through longer developmental periods in marine fish. Limited data make a similar assessment with freshwater or anadromous fishes difficult. However, data on chinook salmon (Johnson, 1965) support the hypothesis. A daily survival rate of 99 percent was calculated for a possible 9-month development period.

The critical period is a relative concept and depends more on the differences of slope in a survival curve rather than absolute rates of mortality. Pearcy (1962) concluded that this concept has limited usefulness, particularly if compensatory mechanisms actively respond to periods of high mortality. The prevalence of compensation in fishes was reviewed by McFadden (1977).

Discussion

Current federal regulations often necessitate entrainment impact modeling in the absence of complete or site-specific data. In the simplistic equivalent adults model (Horst, 1975), larva to adult survival is estimated from data on fecundity, annual survival rates, and egg to larva survival. Other models require additional data on survival rates of larvae and juveniles, population size, larval production, compensatory reserve, etc. Such information is available for a very limited number of species and must be used cautiously in predictive modeling.

Data collected at one site may not be applicable to another if there are differences in natural factors, such as substrate characteristics, disease, water level, dissolved oxygen, water temperature, wave action, predation, cannibalism, food supply, carrying capacity, and condition of spawners. Interaction of more than one stress has been frequently observed. It has been proposed that low water temperatures significantly prolong development and exposure to predation. several stresses may act simultaneously as in smallmouth bass (Latta, 1975), yellow perch (Clady, 1976), salmon (Johnson, 1965), and marine fishes (May, 1974). Skud (1973) concluded that environmental factors had a "random influence" in pink salmon since egg and larval survival was highest when the spawners were large and spawned early. First year survival of smallmouth bass was probably determined by carrying capacity in a stream (Pflieger, 1975).

Natural stresses cause high mortality of eggs in those freshwater species which broadcast the eggs and have no special protective mechanisms. This strategy points to predation as a chronic source of the high mortality in walleye and rainbow smelt. The importance of predation by invertebrates, considered to be the main predators on fish eggs and larvae (Nikolskii, 1969), has received little attention. Larval and nymphal insects and leeches feed on rainbow smelt eggs (Rothschild, 1961).

High egg survival has been reported in freshwater species which cover the nested eggs with gravel (salmonids), deposit eggs in vegetation (carpbream, carp, northern pike), have unique egg mass envelopes (yellow perch) or guard the nests (centrarchids). Many studies have shown over 90 percent survival of demersal eggs of marine species which broadcast the eggs and have no protective mechanisms. However most of these studies probably did not account

for predation which resulted in 15-40 percent mortality in one herring study (Dragesund and Nakken, 1973). The ratio of swim-up larvae and deposited eggs does not provide a reliable measure of egg survival because mortality during the period of hatching and recruitment into the plankton may be high (Forney, 1968; Dragesund and Nakken, 1973). Furthermore, the youngest yolk-sac larvae often associate with the bottom and are not fully vulnerable to plankton sampling gear in freshwaters. Mortality of pelagic eggs has been determined from ratios of various egg stages, but this is tenuous when of short duration such as 1 or 2 days. Polgar (1977) indicated that striped bass eggs were not adequately sampled during the daytime because this species spawns at night. The semibuoyant nature of the eggs may also result in low estimates when sampled with plankton gear. Selection of representative egg survival values is particularly important in the equivalent adults model because of the proportional inverse relationship with the projected adult loss. Because of the sampling problems and natural variability, application of a possible range of survival values is recommended.

Yolk-sac larvae are the most difficult of the three developmental stages to sample because they are frequently extruded through the net in marine studies and are in a transition between a demersal and pelagic existence in most freshwater species. Thus, survival of yolk-sac larvae is generally based on survival curves which exclude data for the smallest larvae or have incorporated correction factors (Lenarz, 1972). Earlier observations of possible critical periods in marine fishes generally reflect this sampling error. Such data gaps do not preclude impact modeling and may represent a minor factor in relation to the various assumptions that are required and the minimal information available on compensatory reserve in fishes.

Development of survival data is lagging far behind the modeling state-of-the-art in impact assessment. As a result, important decisions are being made from incomplete data. A need for further evaluation of models is also evident in the literature. As an example, a series of models for entrainment of striped bass in the Hudson River yielded conflicting results. Major differences in predictions were related to definition of life stages, whether fishing mortality and mortality of larvae and juveniles were density-dependent or density-independent, method of computing recruitment of young-of-the-year fish, and major differences in values of parameters such as egg production, population size, and survival probabilities (Swartzman et al., 1977).

Acknowledgments

Compilation of fish egg and larval survival data has been encouraged by B.C. Marcy, Jr. and other NUS staff who were concerned with power plant impact studies, under the direction of P.V. Morgan, Vice President and General Manager of Ecological Sciences Division. I thank W. J. B. Johnson for drafting the figures. Critical reviews were provided by B. C. Marcy and E. P. Wilkins of NUS Corporation and by S. Gregory and J. Andreasen of the U.S. Fish and Wildlife Service.

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Geographic and Monthly Variation in Composition of Oysters, *Crassostrea virginica*

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Introduction

A review of the cholesterol content of raw oyster meats reported by certain investigators revealed little apparent consistency. Cholesterol levels reported in the literature ranged from 37 mg (Thompson, 1964) to 470 mg (Okey, 1945) per 100 g of oyster meat. Okey indicated, however, that some of the total digitonin precipitable steroids contained sterols other than cholesterol. Composition of Foods, Agriculture Handbook No. 8 (Watt and Merrill, 1963), lists oysters as containing less than 200 mg of cholesterol per 100 g. For a low-cholesterol diet, the National Heart and Lung Institute, National Institutes of Health, recommends the consumption of not more than 9 ounces of oyster meats a day. This judgment was made on the assumption that oyster meats do not contain over 40 mg per 100 g, in which case the intake would be about 250 g (Frederickson et al., 1973).

ABSTRACT—Cholesterol and glycogen contents of oysters, Crassostrea virginica, *harvested each month for 1 year during 1975-76 from upper Chesapeake Bay (Md.), Mobile Bay (Ala.), and Barataria Bay (La.), were determined. The values varied from 38 to 218 mg with an average of 109.4 mg for cholesterol and from 467 to 6,797 mg with an average of 2,355 mg for glycogen per 100 g of raw oyster meat on a wet-weight basis. Chesapeake Bay and Mobile Bay oysters were further analyzed for protein, fat, ash, moisture, and amino acid content. The protein varied from 5.8 to 10.4 g; fat, 1.4 to 3.0 g; ash, 0.6 to 2.3 g; and moisture, 77.7 to 87.0 g per 100 g of oyster meats on a wet-weight basis. Amino acid profiles of the protein were quite similar in oysters harvested from both locations. The variation in values reported in the literature for the composition of oysters may be associated with time of year and area from which the oyster was harvested. The variation is also due to the physiological status of the organism, which is somewhat influenced by temperature and salinity of growing waters and available food.*

The objectives of this study were: 1) To obtain some understanding of the causes for the variation of the cholesterol values reported in the literature for oysters; 2) to observe possible variations in other components—protein, fat, ash, glycogen, and amino acids; and 3) to note the relationships between the aforementioned components in oysters collected regularly over a period of 1 year (1975-76) from Alabama and Maryland.

Materials and Methods

To compare geographical and monthly differences in the composition of the same species, *Crassostrea virginica,* oysters were harvested at the beginning of each month for 1 year (August 1975 to September 1976) from three areas along the coast of the United States—Chesapeake Bay (Md.), Mobile Bay (Ala.), and Barataria Bay (La.).

Maryland samples were 2-year-old, tray-grown, cultchless oysters propagated in the estuaries of the Chesapeake Bay near Shadyside, Md. As soon as they were delivered to the Southeast Fisheries Center (SEFC) College Park Laboratory at College Park, Md., the oysters were shucked, packed in plastic containers, frozen, and stored at -40°F (-40°C). Samples that were to be analyzed for cholesterol and glycogen were packed in dry ice and shipped by air to Louisiana State University, Baton Rouge, La. Samples to be analyzed for proximate composition and amino acids were homogenized and submitted to the analytical group at the College Park Laboratory.

The Alabama oysters were taken to the SEFC Pascagoula Laboratory at Pascagoula, Miss., shucked, packed, and frozen. They were kept in the freezer at -40°F (-40°C) until a shipment was made to the College Park Laboratory or to the Food Science Department, Louisiana

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State University. The College Park samples were homogenized and prepared for analyses in a manner similar to those from Chesapeake Bay.

The Louisiana oysters were taken by the watermen to processors, where they were shucked, packed in pint jars, and transported in refrigerated trucks to Louisiana State University within 6 hours after harvesting. All oyster samples were held at the University at -25°F (-13°C) for subsequent analyses for cholesterol and glycogen, only.

The cholesterol and glycogen determinations were made according to the method described by Grodner and Lanc (In press). The analyses for crude protein and fat were conducted according to the methods described in Horwitz (1970): protein 2.051; ether soluble fat 7.048. Moisture analyses were performed by placing weighed samples in moisture tins and drying them for 16 hours in a forced air oven maintained at 100°C. The ash was determined by placing the weighed samples in a muffle furnace at 550°C for 16 hours. Amino acids were determined with an automatic amino acid analyzer by the method described by Moore et al. (1958).

Results and Discussion

Table 1 lists the amounts of cholesterol determined in the samples of raw oysters harvested each month throughout the year from the three areas. The January and February Maryland samples were lost in transit to Louisiana. Maryland oysters were highest in cholesterol during December 1975 and May 1976 and lowest in July 1976. The average for the nine samples was 92 mg, with a range of 37-124 mg, per 100 g of raw whole oysters. The Alabama oysters contained the most cholesterol during January, March, and April 1976. The February value does not fall in line with the aforementioned months. The apparent anomaly cannot be explained. The lowest cholesterol levels occurred from July through September 1976. For the year, the average was 107 mg with a range of 57-159 mg per 100 g of oyster meat. In general, the Louisiana oysters contained the most cholesterol—125 mg, with a range of 97-218 mg per 100 g for the year. The overall average for the samples analyzed in this study was 109.4 mg, with a range of 37-218 mg per 100 g. Statistically, there is no significant difference among the cholesterol values from the three areas.

A limited number of values have been reported in the literature for the cholesterol content of *C. virginica*. Thompson (1964) reported 58 mg of cholesterol in oysters harvested in November from the upper Chesapeake Bay, as compared to 77 mg per 100 g reported in this study. For the same species harvested in January near Biloxi, Miss., a value of 37 mg was obtained, compared to 157 mg for oysters harvested in nearby Alabama Bay. Although the times of the year that the oysters were harvested were not recorded by Achard et al. (1934), Koga (1970 a, b), Shimma and Taguchi (1964), Kritchevsky and Tepper (1961), and Kritchevsky et al. (1967), the values they reported fall within the limits of the values obtained in this study. The physiological status of animals harvested at different times from the same area clearly can be one of the causes for the variation in cholesterol content. In addition, some of the variation between areas may be associated with salinity and temperature of the water.

Table 2 records the amount of glycogen found in raw oysters from three areas throughout the year. The yearly average was lowest for the Louisiana oysters, 1,326 mg (range 467-2,960 mg); Alabama was second, 2,495 mg (range 603-4,155 mg); and Maryland third, 3,539 mg (1,919-6,920 mg) per 100 g of raw oyster meat. The data from each area are correlated with each other, indicating they form the same shape curve. When the data were fitted to a sine curve to test for annual cyclic trends, they conformed significantly with the peak in the same area of the curve.

The Maryland and Alabama oysters appear to be fattest during March, April, May, and June. This concurs with the results reported by Lee et al. (1960). In the Lee et al. (1960) investigations of gulf oysters, glycogen content was obtained by the difference between the sum of protein, fat, ash, and moisture content and 100 percent.

When the data for the three areas were pooled to determine if a correlation exists between the cholesterol and glycogen content of oysters, it was determined that there was no significant relationship (r=0.15). Therefore, a high cholesterol value does not necessarily imply a large amount of glycogen.

Table 3 shows the average and range of the values for the proximate composition of the same lots of monthly samples from the coastal waters of Alabama and Maryland used in the cholesterol and glycogen determinations. Maryland samples were collected from August 1975 to August 1976; therefore, there are 13 lots in this phase of the study. Alabama samples were collected from September 1975 to September 1976, but there are 12 lots since the July 1976 lot was not analyzed. To facilitate the direct comparison of the oysters from the two areas, the values on both a dry-weight and wet-weight basis are recorded. Also,

Table 1.—Cholesterol values of oysters, *Crassostrea virginica*, harvested monthly for 1 year (1975-76) from three areas.

		Mg/100 g of oyster tissue		
Month	Year	Alabama	Louisiana	Maryland
October	1975	[1]108	[1]103	[1]106
November	1975	109	142	77
December	1975	116	109	124
January	1976	157	129	—[2]
February	1976	76	164	—[2]
March	1976	140	117	105
April	1976	148	107	94
May	1976	124	106	123
June	1976	109	98	91
July	1976	77	218	37
August	1976	57	97	69
September	1976	65	108	—[2]
Average		107	125	92

[1]Average of two determinations.
[2]Sample missing.

Table 2.—Glycogen values of oysters, *Crassostrea virginica*, harvested monthly for 1 year (1975-76) from three areas.

		Mg/100 g of oyster tissue		
Month	Year	Alabama	Louisiana	Maryland
October	1975	[1]603	[1]876	[1]2,510
November	1975	1,322	467	1,929
December	1975	1,925	1,374	1,919
January	1976	2,211	1,827	—[2]
February	1976	2,117	2,349	—[2]
March	1976	4,069	1,597	3,346
April	1976	4,155	1,333	4,973
May	1976	6,797	2,960	6,920
June	1976	3,731	968	4,098
July	1976	953	836	3,135
August	1976	916	606	3,017
September	1976	1,143	715	—[2]
Average		2,495	1,326	3,539

[1]Average of two determinations.
[2]Sample missing.

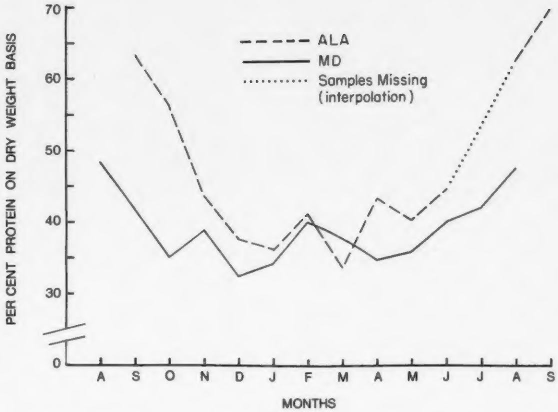

Figure 1.—Comparison of protein content in the monthly samples of freshly harvested oysters from Alabama and Maryland during 1975-76.

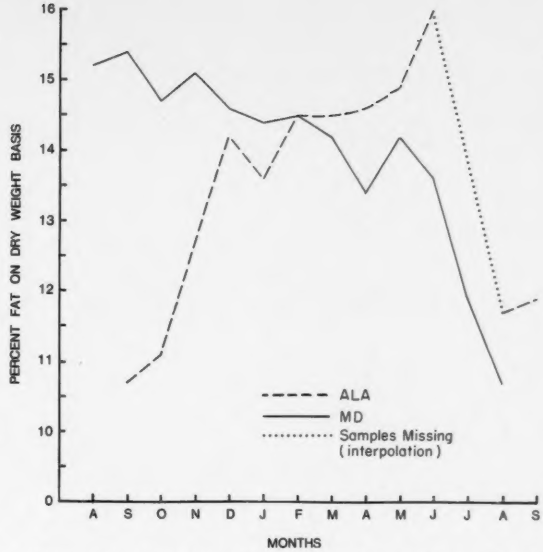

Figure 2.—Comparison of fat content in the monthly samples of freshly harvested oysters from Alabama and Maryland during 1975-76.

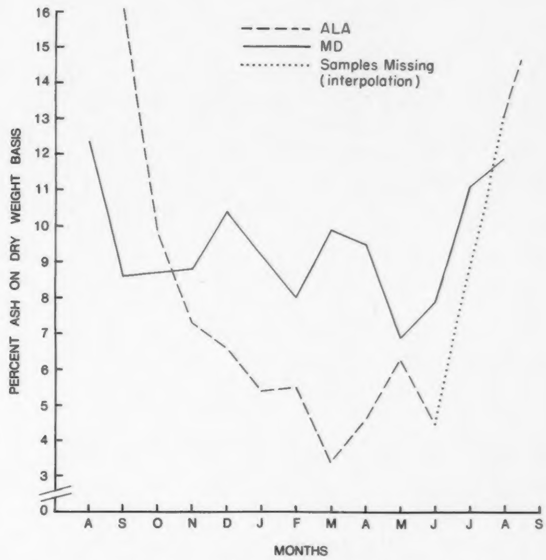

Figure 3.—Comparison of ash content in the monthly samples of freshly harvested oysters from Alabama and Maryland during 1975-76.

the data on dry-weight basis are graphically reported in Figures 1, 2, and 3.

Figure 1 shows the fluctuation in protein content of the oysters harvested monthly over a 1-year period from Alabama and Maryland waters. Between December and April, the protein content of the oysters is low in both harvest areas compared to the other months of the year. The protein ranged from 32.5 to 34.8 g during these months for the Maryland oysters and from 35.6 to 41.1 g for the Alabama oysters per 100 g of dried meat. Protein content was higher during the summer and early fall, before harvest season. Protein content of the Alabama oysters is significantly (p=0.01) higher than that of the Maryland oysters. The sine curves formed by the data from both sites are the same, except the values for Alabama oysters were higher than for Maryland oysters. These curves had a significant fit to sine curves with peaks in August to indicate an annual cycle.

The 11 values for protein reported in the literature for this species ranged from 5.2 to 10.0 g (Sidwell, in press). The range of the protein content in the oysters used in this study was very similar (5.6-10.3 g per 100 g) on a wet-weight basis. Venkataraman and Chari (1951) reported a similar seasonal variation in this species of oysters harvested from Indian waters.

Table 4 presents the amino acid profile of the protein found in oysters. As expected, the profiles for oysters harvested monthly from Alabama and Maryland waters are similar, because the amino acid pattern of the protein is species oriented. In contrast, the amount of protein in the oyster is influenced by

Table 3.—Proximate composition of oysters, *Crassostrea virginica*, harvested monthly for 1 year (1975-76) from two areas.

Area	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Glycogen (%)
Alabama					
Dry weight		[1]47.0	[1]12.9	[1]8.1	[1]14.4
		[2]33.9-70.1	[2]10.8-14.6	[2]3.1-16.2	[2]4.4-30.4
		[3]12	[3]12	[3]12	[3]11
Wet weight	83.4	7.6	2.2	1.3	2.5
	77.7-87.0	6.1-10.4	1.4-3.0	0.6-2.3	0.6-6.8
	12	12	12	12	12
Maryland					
Dry weight		39.2	14.0	9.5	20.0
		32.5-48.4	10.7-15.4	6.9-12.3	10.6-39.2
		13	13	13	9
Wet weight	82.7	6.7	2.4	1.6	3.5
	80.6-85.0	5.8-7.9	1.7-2.9	1.2-2.0	1.9-6.9
	13	13	13	13	9

[1]Average.
[2]Range of values.
[3]Number of values used to calculate the two statistics.

Table 4.—Amino acid profile of the protein in oysters, *Crassostrea virginica*, harvested monthly for 1 year (1975-76) from two areas.

	% of total protein					
Amino acids	Alabama			Maryland		
Lysine	[1]8.4	[2]6.6-11.0	[3]12	[1]7.6	[2]5.6-9.6	[3]13
Histidine	2.1	1.7-2.4	12	2.4	2.0-3.0	13
Arginine	6.4	5.4-7.1	12	6.3	5.0-8.8	13
Aspartic acid	9.8	8.8-11.2	12	10.4	9.0-12.2	13
Threonine	4.1	3.6-5.0	12	4.2	3.6-4.7	13
Serine	4.8	4.2-5.2	12	4.9	4.2-5.6	13
Glutamic acid	14.0	11.4-15.0	12	12.8	11.2-14.4	13
Proline	4.4	3.8-5.2	11	4.1	3.6-4.6	10
Glycine	5.1	4.5-5.8	12	5.2	4.5-5.7	13
Alanine	5.5	4.9-6.0	12	5.1	4.6-5.7	13
Valine	4.6	3.6-4.8	12	4.2	3.7-4.6	13
Methionine	2.0	1.6-2.4	12	2.0	1.1-2.3	8
Isoleucine	3.7	3.2-4.4	12	3.8	3.4-4.2	13
Leucine	6.6	5.6-7.4	12	6.3	5.4-7.2	13
Tyrosine	3.3	2.6-3.8	12	3.2	2.4-3.8	12
Phenylalanine	3.4	2.5-4.0	12	3.4	2.4-3.8	13

[1]Average.
[2]Range of values.
[3]Number of analyses.

external factors, such as the availability of the food from the surrounding environment.

Figure 2 illustrates the monthly variation in the fat content of the Alabama and Maryland oysters. On a dry-weight basis, the fat content of Maryland oysters averaged 14.0 g, with a range of 10.7-15.4 g per 100 g; Alabama oysters averaged 12.9 g, with a range of 10.8-14.6 g per 100 g. The seasonal trend of the fat content in the Alabama oysters was quite clearly defined. It was low in September for both 1975 and 1976, peaking in June with a decline in August. Lee et al. (1960) observed the low point to occur in July for southern oysters collected at various points along the Gulf of Mexico coast. This trend was not noted for the Maryland oysters. Fat content on a dry-weight basis was 15.2 g in August 1975 and 10.7 g in August 1976. There was a steady decline throughout the year in the fat content of Maryland oysters.

There was no significant difference between the data on the fat content of oysters from the two areas. The Alabama data fit significantly to a sine curve with a peak in March, April, and May. This was not so for the Maryland data.

There is no significant correlation (r=0.32) between the fat and cholesterol content in oysters harvested from the Chesapeake and Mobile bays when the data are pooled. Separately, there is a significant correlation between fat and cholesterol content (r=0.80) of the Maryland oysters, but not so of the Alabama oysters (r=0.47).

In this study, no effort was made to study the character of the fat in oyster muscle. Bonnet et al. (1974) reported that 28.1 percent of the fat was saturated; 10.6 percent contained one bond; 61.3 percent contained more than one bond.

Figure 3 shows that the ash content of oysters varies with season. It appears to be high during the late summer and lower in the winter and spring months. Again, this phenomenon is more clearly defined in the Alabama oysters. The ash data for the Alabama oysters significantly fits the sine curve with a peak in September. This is not true for the Maryland data.

Table 5 shows that the ash content appears to be inversely related to the fat content of the oyster muscle. This accumulation of mineral salts (ash) may be a physiological effort by the animal to maintain cellular osmotic pressure. On the other hand, there may be a greater accumulation of sandy materials in the gut during certain times of the year. There is a significant correlation between fat and ash content of Alabama oysters but not Maryland oysters.

Figure 4 shows graphically the relationship between the three components, protein, cholesterol, and glycogen, in the whole Alabama oyster during the various months of the year. There is a tendency for cholesterol and glycogen to be high at about the same time the protein is low. The Maryland oysters (Fig. 5) show a similar trend but it is not as clearly defined as in the Alabama oysters.

Table 5.—Fat and ash content on a dry-weight basis in oysters, *Crassostrea virginica*, harvested in 1975-76 from the coastal waters of Alabama and Maryland.

	Alabama		Maryland	
Month	Fat (%)	Ash (%)	Fat (%)	Ash (%)
1975				
September	10.7	16.1	15.4	8.6
October	11.1	9.8	14.7	8.7
November	12.7	7.3	13.1	8.8
December	14.2	6.6	14.6	10.4
1976				
January	13.6	5.4	14.4	9.1
February	14.5	5.5	14.5	8.0
March	14.5	3.4	14.2	9.9
April	14.6	4.6	13.4	9.5
May	14.9	6.3	14.2	6.9
June	16.0	4.5	13.6	7.9
July	—	—	11.9	11.1
August	11.7	13.1	10.7	11.9

The apparent variation in values for the cholesterol and glycogen content of oysters, *C. virginica*, reported in the literature is associated with the time of the year, and possibly with the area from which the oysters are harvested. It is

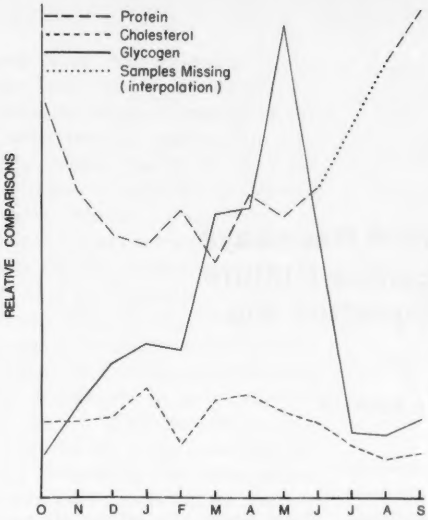

Figure 4.—Comparison of amounts of protein, cholesterol, and glycogen present in the monthly samples of freshly harvested oysters from Alabama during 1975-76.

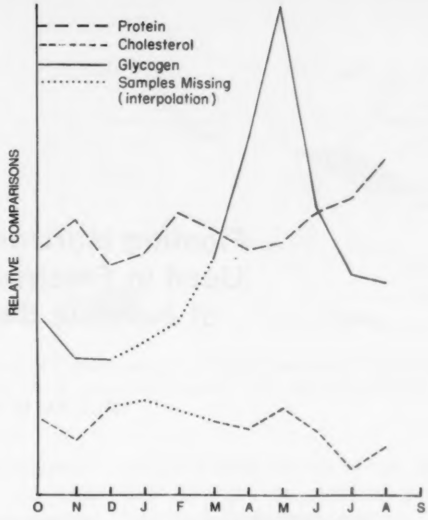

Figure 5.—Comparison of amounts of protein, cholesterol, and glycogen present in the monthly samples of freshly harvested oysters from Maryland during 1975-76.

logical to conclude that variation is due to the physiological status of the organism, which is associated with environmental conditions like temperature and salinity of the water, as well as to the available food. The amount of other food components, e.g., protein, fat, and ash, in the whole oyster is probably influenced by the same factors.

In this study the results were often not statistically significant because of the small sample. To obtain data that will characterize the cyclic nature of the composition of the oyster, it will be necessary to collect data over a period of at least 2 years. Each monthly lot of oysters should be subsampled to obtain some information on the variability within each sample. Also, a description of the physiological status of the animals used in the analysis should be observed to help explain some of the variation.

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Floating Horizontal and Vertical Raceways Used in Freshwater and Estuarine Culture of Juvenile Salmon, *Oncorhynchus* spp.

WILLIAM R. HEARD and ROY M. MARTIN

Introduction

Salmonid culturists commonly use a wide variety of containers including raceways and ponds of various types (Burrows and Chenoweth, 1955, 1970), circular tanks (Larmoyeux, et al., 1973), and vertical drums and silos (Buss, et al., 1970). Frequently new modifications are developed in response to specific requirements associated with a particular fish culturing activity.

In 1973 we began experimentation with the use of raceways floating in the estuary of Little Port Walter Bay, Baranof Island, southeastern Alaska, where the Northwest and Alaska Fisheries Center Auke Bay Laboratory maintains a year-round field station to conduct a variety of salmonid research programs (Fig. 1). We developed the floating raceways as a tool in our efforts to determine the practicality of rearing coho salmon, *Oncorhynchus kisutch*, fry to smolts in estuarine net pens (Heard and Crone, 1976; Heard et al.[1]). In this paper we describe the construction and operation of the horizontal and vertical floating raceways we are using at Little Port Walter.

The culture of newly emerged salmon fry (0.2-0.4 g depending on species) in net pens requires openings no larger than 1/8 inch square mesh to retain the fish. Most other pen culture of salmonids begins with fish larger than fry and larger openings (mesh sizes) can be used. In the Puget Sound area salmon are raised to smolt size (usually 10-15 g) before they are put into pens in the estuary for raising to pan size (Novotny, 1975). Salmon of this size range generally can be cultured in pens made with square mesh openings of 1/4-3/8 inch.

When salmon fry are cultured in net pens the required small meshes must be cleaned frequently or they become

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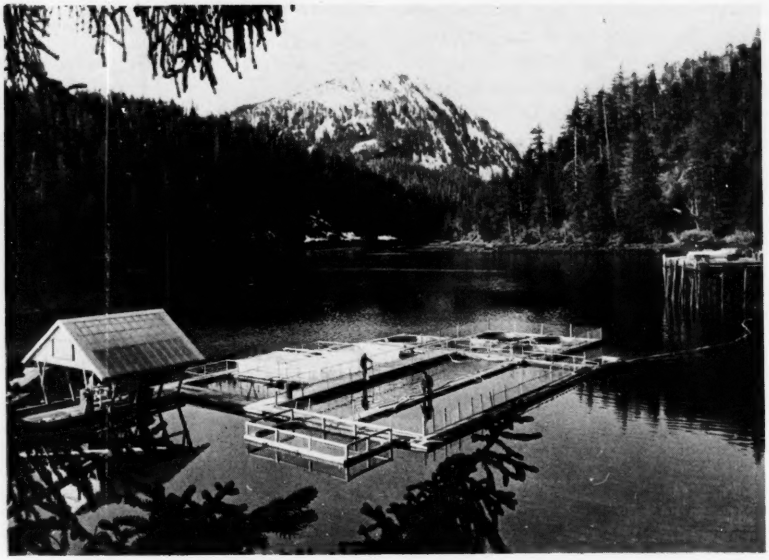

Figure 1.—Floating salmon culture facility at Little Port Walter Bay, south Baranof Island, Alaska, showing general array of horizontal and vertical raceways and net pens. Floating hose on surface is used to transport fry from shore-based incubation station (out of view) to the floating culture unit.

[1]Heard, W. R., R. M. Martin, and A. C. Wertheimer, 1973. Report of progress on the feasibility of salmon smolt production in estuarine husbandry pens at Little Port Walter, January 1-June 1973. Unpubl. manuscr., 13 p. Northwest and Alaska Fisheries Center Auke Bay Laboratory, Auke Bay, AK 99821.

clogged with biofouling growths, uneaten food, and fecal matter. An alternative to frequent cleaning of the pens while they are holding fry is to regularly transfer the fry to clean net pens. However, frequent in situ cleaning of fouled meshes, transferring or handling of fry, or inadequate sanitation all stress the fish which can encourage disease or reduced growth (Wedemeyer and Wood, 1974; Wood, 1974).

The use of floating raceways at Little Port Walter grew, in part, from the need to find alternatives to mesh pens for culture of fry. Experimentation with these units has led to year-round culture from fry to smolt in fresh water and in controlled intermediate saline water—operations not possible in estuarine net pens. Other advantages of the floating raceways over their shore-based counterparts include lower cost and simplified construction.

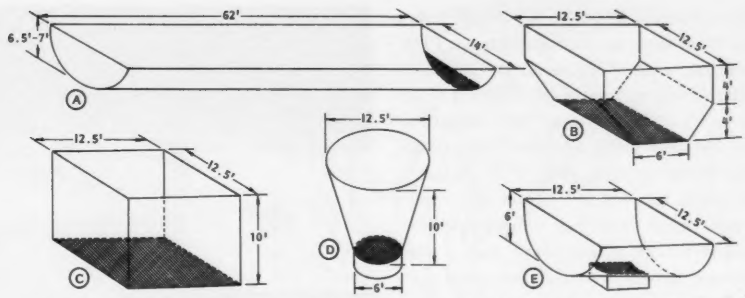

Figure 2.—Schematic diagrams of floating raceways designed and tested at Little Port Walter between 1973 and 1976. A, horizontal raceway; B-E, vertical raceways.

Design, Construction and Use

Basically, the floating raceways are containers of lightweight, relatively inexpensive, nylon-reinforced plastic fabric with a one-way flow of water. A floating log or styrofoam framework, from which the liners are suspended, provides rigidity. Floating raceway shapes are determined by design and by maintaining a slight hydraulic head normally 0.5-1.0 inch over the surrounding water. Flow of water through the units is determined by location of inlet water and an outlet "drain." The drain is usually made from nylon netting sewn into the plastic fabric. The raceway is formed by attaching the upper edge of the plastic fabric to the float frame with wood battens, generally allowing 4-8 inches between the water surface and the top of the liner.

We designed and tested five shapes of floating raceways at Little Port Walter between 1973 and 1976 (Fig. 2). The design and extent of testing of each shape depended on available material, available waterflow, and the specific requirements for particular test lots of fish. The raceways were designated as horizontal (Fig. 2A) or vertical (Fig. 2B-E), based in part on shape and on the direction of waterflow.

Three weights or thicknesses, light-, medium-, and heavy-weight, of impervious plastic material were used in constructing the raceways. Light- and medium-weight materials were used in prototypes and intended to last for a few weeks or months. The heavy-weight material was used in working units intended to last for several years. The plastic fabrics had nylon or polyester lamination that made them resistant to tears although sharp objects could puncture the material. The light material weighed 0.25 pound/square yard and was made of polyethylene with approximately two nylon fiber meshes per inch. The medium-weight material weighed 0.50 pound/square yard and was made of vinyl with approximately four polyester fiber meshes per inch. The heavy material weighed 1.25 pound/square yard and was made from vinyl with approximately 14 nylon fiber meshes per inch. The heavy material is called C-Lite vinyl-coated nylon fabric.[2]

All of the floating raceways were constructed from mill-run widths of the plastic materials. The appropriate pieces were double-stitched and sewn together with a heavy-duty sewing machine using dacron or nylon threads.

The flow of controlled intermediate salinity water through the floating raceways is accomplished with a simple venturi device that injects seawater into the freshwater delivery system. Salinity and flow can be regulated by using interchangeable component parts of the venturi and stable salinities of up to 20‰ can be maintained for several months (Heard and Salter, 1978).

Horizontal Raceways

The horizontal raceways are semicylindrical in cross section and the water flows in one end and out the other (Fig. 2A). Two prototype horizontal units were used for 13 weeks in 1973 to culture 1972 brood coho salmon, *O. kisutch*, in fresh water and at intermediate salinities of 7 ‰ (Heard et al.[3]). These two units, approximately 40 feet long, 6 feet wide, and 2 feet deep, were constructed from the light polyethylene-nylon material. Three parallel logs with heavy timbers across their ends provided the floating frame. The drain consisted of a 4-inch diameter outlet at the downstream end screened with nylon webbing containing ⅛-inch square mesh openings.

Two larger horizontal units were used to culture 1974 brood coho salmon over a 1-year interval during 1975 and 1976 (Heard et al.[4]). These larger units,

[2]The plastic material used to build the floating raceways and ponds was sold under C-Mesh and C-Lite trade names by Canton Containers Division of Northern Petrochemical Company, Canton, Ohio. Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

[3]Heard, W. R., R. M. Martin, and A. C. Wertheimer. 1974. Progress report on 1972 brood year coho salmon fry-to-smolt rearing in estuarine pens at Little Port Walter, July 1-December 31, 1973. Unpubl. manuscr., 21 p. Northwest and Alaska Fisheries Center Auke Bay Laboratory, Auke Bay, AK 99821.

[4]Heard, W. R., R. M. Martin, and A. C. Wertheimer. 1977. Estuarine and freshwater culture of 1974 brood coho salmon in net pens and floating raceways at Little Port Walter. Unpubl. manuscr., 55 p. Northwest and Alaska Fisheries Center Auke Bay Laboratory, Auke Bay, AK 99821.

approximately 62 feet long, 14 feet wide, and 7 feet deep, were constructed in 1975 from the nylon-reinforced heavy vinyl material. These units were designed to fit into part of the general float structure used for suspending net pens in the Little Port Walter estuary (Fig. 1, 3). Initially the outlet was a 4-foot^2 piece of ¼-inch square mesh webbing sewn into the bottom of the downstream end of the raceway. Subsequent trials indicated that a 2-foot^2 drain was adequate for the low flows (exchange rates) we were using. To retain small fish capable of escaping through ¼-inch square mesh openings, a temporary overlay panel of ⅛-inch square mesh webbing was attached with Velcro[5] fastening tape over the permanent panel. The overlay of smaller mesh webbing was easily removed when fish had grown enough to be retained by the larger mesh openings.

Figure 3.—Horizontal floating raceways at Little Port Walter.

Vertical Raceways

In the vertical raceways (Fig. 2B-E) the water flows in at the top and out at the bottom. These units were all built to fit the flotation frames we had on hand which were initially designed and built by the Alaska Department of Fish and Game for suspending net pens. These frames had a 12.5-foot^2 opening, a 2.2-foot-wide walkway around the opening, and were approximately 17 feet^2 overall.

Two 8-foot-deep vertical raceways. (Fig. 2B) were used to culture approximately 22,000 1973 brood sockeye salmon, *O. nerka* for 9 weeks in 1974; half of the salmon were maintained in fresh water and half were maintained at 15‰ salinity (Heard et al.[6]). These two raceways were made of the medium vinyl-polyester material. They measured approximately 12.5 feet by 12.5 feet at the top and at the upper 4-foot depth, and tapered to an 8-foot by 8-foot outlet drain opening in the lower 4-foot depth. The bottom was 3/16-inch square mesh nylon webbing.

Figure 4—Conical-shaped vertical floating raceways at Little Port Walter.

Vertical raceways rectangular in shape with a cross section of about 12.5 feet by 12.5 feet and a depth of 10 feet (Fig. 2C) were constructed in May 1975 of the nylon-reinforced heavy vinyl material. Initial testing revealed difficulties in maintaining the designed shape of these units due to the greater density of the seawater (28-32 ‰) surrounding the units relative to the density of the fresh or intermediate salinity water inside the units—the whole unit tended to float. The lower portion of the units hung unevenly, even with 250-300 pounds of weights added along the bottom edge. Salinity intrusions were evident by the presence of sharp haloclines inside the unit above the mesh bottom.

Modification of the rectangular-shaped vertical raceways led to the inverted frustrum (conical) design (Fig. 2D, 4). Under most conditions the

[5]Reference to trade names or commercial products does not imply endorsement by the National Marine Fisheries Service, NOAA.
[6]Heard, W. R., R. M. Martin, and A.C. Wertheimer. 1975. Progress report on estuarine husbandry research of 1972 and 1973 brood salmonids at Little Port Water, Alaska, January 1-December 31, 1974. Unpubl. manuscr., 39 p. Northwest and Alaska Fisheries Center Auke Bay Laboratory, Auke Bay, AK 99821.

conical-shaped vertical raceways keep their design shape in the water. An 18-inch velum-like extension below the bottom mesh prevents unwanted seawater intrusions. Weights can be added along the lower edge of the velum to help maintain the intended shape and orientation of the conical units.

The first two conical units were used to culture 20,000 1974 brood coho salmon at 7-9 ‰ salinities from July 1975 until they were released in spring 1976 (Heard et al., footnote 4). These units were 13 feet in diameter at the top opening, 6 feet in diameter at the bottom opening, and 10 feet in depth along the mid-line. The bottom outlet was a permanent ¼-inch square mesh panel attached with Velcro tape.

Four additional conical units, identical in shape and dimension to the first two but with a permanent drain panel of ⅛-inch square mesh for the bottom outlet, were used in spring and early summer 1976 for 30- to 90-day culture of 1975 brood pink salmon, *O. gorbuscha*, fry at intermediate salinities. Similar conical units were also used in a variety of applications involving culture of 1975 brood coho salmon fry, fingerlings, and smolts in fresh water and intermediate salinities.

The floating raceway illustrated in Figure 2E is a shortened version of the horizontal raceway, modified so the outlflow is through a drain in the bottom. This produces a vertical rather than a horizontal flow. We used one unit of this design for 5 weeks in 1976 for the initial feeding of 1975 brood coho salmon. The unit was 12.5 feet by 12.5 feet at the top and about 6 feet deep and was constructed from the heavy vinyl material. The drain was 1 foot^2 of ⅛-inch square mesh nylon webbing and had a 1-foot velum extending below the webbing.

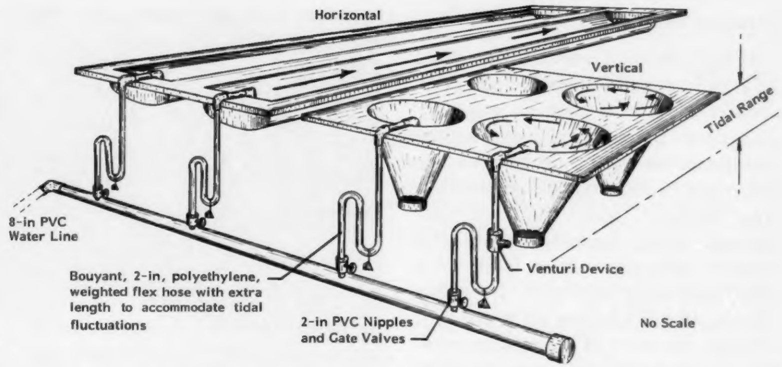

Figure 5.—Schematic diagram of plumbing system used to deliver waterflow to the floating raceways at Little Port Walter.

Operation of Floating Raceways

Floating raceway operation involved several factors including water delivery, snow and ice accumulation in winter, raceway cleaning, fish sampling, and predator control. A major distinction between culturing juvenile salmon in net pens and in floating raceways is that while net pen culture depends on movements of tidal currents through the meshes to maintain a suitable environment, floating raceways require a system of controlled, directed water delivery to provide suitable water exchanges. The water delivery system for the floating raceways at Little Port Walter is described below.

Water Delivery

Fresh water is gravity fed from Sashin Creek across the bottom of the estuary via a 6-inch line (1973 and 1974, 8-inch after 1974). Water is passed from the main line through a manifold into 2-inch diameter flexible polyethylene hoses which lead up to the floating raceways. The flexible hoses were needed to compensate for fluctuations in tidal height (Fig. 5).

When water of intermediate salinity was needed, a venturi device was plumbed into the flexible hose below the low salinity surface water of the estuary (>3 feet). Seawater (28-31 ‰) injected into the freshwater flow through the venturi device provided a fairly stable intermediate salinity (from 1 to 20 ‰) flow. The blend of fresh water and seawater—hence the specific salinity—was determined by variable features of the venturi (Heard and Salter, 1978).

Because of continuous and concomitant changes in hydraulic head caused by tidal fluctuations, precise flow rates to the units could not be maintained. Daily changes in elevation ranged from 4 to 15 feet. In 1973 and 1974, waterflows in the floating raceways varied roughly fourfold (0.1-0.4 exchanges per hour) between the lowest and highest tides. The 6-inch line used in these years had only 2 feet of hydraulic head above the highest tides; consequently, flows were lowest at high tide. In 1975 and 1976, waterflows only fluctuated 10-20 percent between high and low tides because the 8-inch line delivered water from a hydraulic head of 120 feet above the high tide level. Loading densities of fish in the floating culture units generally were maintained between 0.2 and 0.6 pounds of fish per cubic foot of rearing volume and were based on the minimum flows that occurred at high tide.

Snow and Ice Problems

During the winter we have had to remove heavy snowfalls from the walkways around the floating raceways (Fig. 6) and adjust the inflowing water to reduce ice formation in the units, especially in the horizontal raceways with the larger surface areas and fresh water. To reduce ice formation on these raceways, surface agitation was increased by augmenting the waterflows and adding extra inflow points throughout the unit. If the horizontal raceways had been using intermediate salinity water, surface ice formation would have been reduced due to its greater warmth and lower freezing point. Intermittently, ice up to 8-10 inches thick forms over most of the Little Port Walter estuary, but this ice causes no disruptions in the flow of water to the raceways.

Cleaning Raceways

In the horizontal raceways, depending on flow rates and water velocities, some uneaten food, fecal material, and other loose debris was moved along the bottom and flushed through the mesh drain at the outlet end. Material that did not flush out was removed with an underwater vacuum device connected by flexible hose to either the suction intake of a centrifugal pump or venturi. The gently curving sides and bottom permitted easy, efficient operation of the vacuum head. The raceways shown in Figure 2 could be completely cleaned by vacuum in 15-20 minutes. Depending on densities of fish, feeding rates, and water temperatures, these units were cleaned at 1- to 7-day intervals.

The vertical raceways had important self-cleaning characteristics because of the downward spiraling flow of water and high density of most debris. The conical units were almost totally self-cleaning (especially with ¼-inch square mesh webbing in the bottom)—two of these units were used for 9 months with no accumulation of food or feces. During this period the only items to accumulate on the bottom of the conical units were an occasional dead or distressed salmon and a few dead marine organisms that entered the inflow water through the unscreened suction intake of the venturi and subsequently died from reduced salinity.

Hunter and Joyner (1975), in testing a scale Plexiglas model of a floating cylindrical tank with the drain located at the apex of a conical-shaped bottom, found no accumulated wastes during 3 weeks of observation.

Growths of algae on the inside walls of both the horizontal and vertical units were removed at infrequent intervals with long-handled brushes and squeegees. Occasionally a neoprene-suited diver entered the vertical units to clean algae from the lower portion of the unit. During the initial testing in 1973 and 1974, there was a rapid buildup of marine growth on the outside of the floating raceways, primarily barnacles, mussels, and tunicates, so the outside surfaces of all subsequent units were coated with copper-based marine antifouling paint.

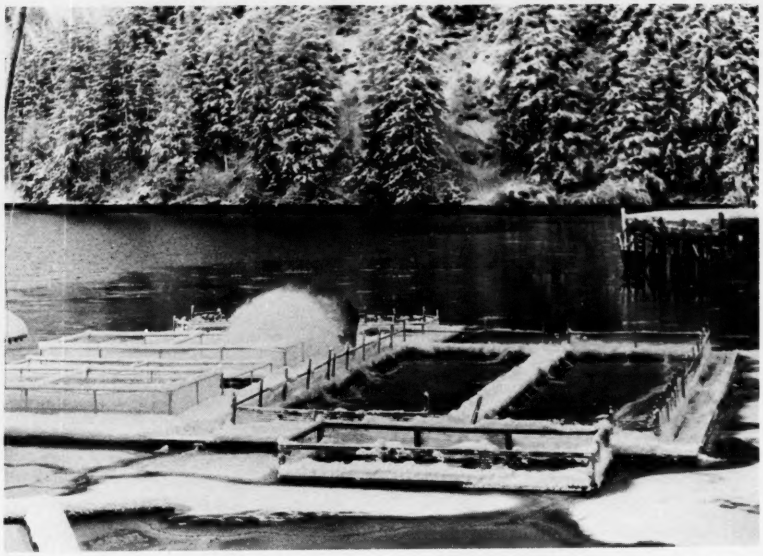

Figure 6.—Winter scene at floating salmon culture facility at Little Port Walter showing snowblower removing snow from walkways around raceways and net pens.

Sampling and Removing Fish

Different techniques were used for collecting fish in floating horizontal and vertical raceways. In the horizontal raceways, conventional seines or dip nets were used to crowd fish toward one end where a lift net previously set along the bottom and sides of the unit was raised to capture the fish. Fish were then pursed into a small area and easily captured. In the vertical raceways, a 12-foot deep seine was lowered along the sides of one-half the periphery of the unit then slowly worked across the bottom and up the opposite sides. Aluminum poles and ropes were used to keep the seine webbing in close contact with the sides and bottom of the ponds. This technique is similar to one described by Buss et al. (1970) for removing fish from a 16.5-foot-deep silo and is quite effective. Usually over 99 percent of the fish were captured with two or three sets of the net. Sometimes, when we wanted to remove all the fish, a diver entered the raceway with a small seine with brails and a deep bag and captured the last few fish.

Predator Control

Because the floating raceways have a low profile, land otters, *Lutra canadensis*, and mink, *Mustela vison*, could readily enter them, so precautions were taken to keep the animals out. Initially, covers of small mesh nylon webbing were stretched over the units. Although the covers kept these predators out, they made it difficult to see the fish and accumulated snow during heavy snowfall. Critical observation of fish in the raceways was necessary to evaluate feeding and other behavior which are important indicators of general fish health. A hardware-cloth fence, with 1-inch mesh and 18-30 inches high, kept most mustelids out and permitted easy viewing of the fish.

Birds that fed in the floating raceways included gulls, *Larus* spp; kingfishers, *Megaceryl alcyon;* and water ouzels, *Cinclus mexicanus*. A cover of large-mesh, fine-thread, gillnet webbing stretched over the hardware-cloth fence was effective against all birds except the water ouzel. This small bird was not considered a serious predator due to its size and its territorial defensiveness which resulted in only one individual feeding in the raceways.

The most effective protection from predation by both mammals and birds was a trained dog although one was not always available.

Discussion

Four years' experimentation with floating raceways at Little Port Walter have shown them to be a useful fish culture tool. They are effective alternatives to small-mesh net-pens for culture of small fry and are suitable year-round for fresh water or intermediate salinities.

Horizontal and vertical raceways each have special advantages. Vertical raceways, especially the conical design, have self-cleaning characteristics even at low exchange rates. Horizontal raceways are easy to clean with vacuum heads. They have more favorable volume-to-surface ratios than the vertical types (Buss et al., 1970) and would probably yield higher production for a given amount of flowing water. Fish are easier to observe in the horizontal raceways but the larger surface area did prove more troublesome because of ice during winter.

We made no evaluations of the hydraulic performance of the floating raceways at high exchange rates. Our exchange rates were generally less than 1 per hour, which, according to Westers (1970), is undesirable for production hatcheries. Based on our experience with the general concept and utility of floating raceways at relatively low stocking densities and low exchange rates, we believe these designs could be useful at higher production-level stocking densities and flows.

Acknowledgments

Much of the equipment, materials, and financial support, for this work came from cooperative research agreements with the Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development (FRED). A. C. Wertheimer, R. A. Crone, P. A. McCollum, R. Vallien, H. W. Kopperman, and S. Schmitt did much of the field work associated with this study.

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Fisheries Development Task Force Formed

A Department of Commerce task force on fisheries development policy has been formed to examine problems affecting the growth of the fishing industry in the United States. The Department-wide task force is under the leadership of Frederick A. Schenck, Deputy Under Secretary of Commerce, and James P. Walsh, Deputy Administrator, National Oceanic and Atmospheric Administration. Members of the fisheries industry and Congressional staff will be included in the task force's work.

"The work of the Fisheries Development Task Force is among the most important of current Departmental activities," said Schenck. "It will mobilize our resources on behalf of an industry with considerable development potential and show how the wide variety of resources found in the Department and elsewhere can be integrated."

Walsh said that it has become increasingly clear that if the United States is to take full advantage of the resources within the 200-mile fishery conservation zone, government must work with industry in a cooperative manner. "We must develop a capability to catch the fish that are available and supplant the foreign fishing off our shores," said Walsh. "In addition, there is a real need to develop the many resources found off our coasts that are not being used by anyone."

The benefits obtainable through fisheries development are quite substantial. Scientists estimate that there are enough fish and shellfish within the conservation zone to double or triple the amounts of seafood landed in the United States.

"An increase of this size would provide substantial benefits in terms of employment and gross national product, help to stabilize the fishing industry, decrease the rate of inflation in fishery prices, and greatly reduce the United States' present $2.1 billion deficit in international trade of fishery products," said Schenck.

The task force will develop: 1) A proposed Executive Branch program for fisheries development; 2) a series of background papers on major concerns that must be considered in making decisions on the role of the Federal Government in fisheries development. In addition, there will be several investment analyses of selected individual fisheries that appear to have development potential. These analyses will pinpoint opportunities, specify constraints to development, and propose options to eliminate these constraints; 3) a proposal to streamline regulations which are burdensome or of questionable value to the fishing industry; and 4) a fisheries assistance handbook that will explain the Federal resources and services presently available to the fishing industry and how they may be obtained.

In its work, the task force will study the results of the Department's nearly completed Export and Domestic Market (Wexler) Study along with the background papers and investment analyses. The Wexler study is a year-long comprehensive review of marketing opportunities for U.S. seafood products in the United States and 15 major fish and shellfish consuming nations in Western Europe, Africa, and the Far East. In addition, the study has identified the major impediments to development of those U.S. resources with significant growth potential. The results of the task force are scheduled to be available early next spring.

In addition to the Office of The Secretary and NOAA, other major agencies involved in the task force are the Economic Development Administration, Industry and Trade Administration, Office of Science and Technology, Maritime Administration, Office of Minority Business Enterprise, and four of the Department's Regional Action Planning Commissions. Co-ordination with other agencies will take place as required.

OCZM MERGES WITH OCEAN MANAGEMENT

The Offices of Coastal Zone Management and Ocean Management have merged, according to NOAA Administrator Richard A. Frank. The merger, anticipated for some time, became effective 1 October on an interim basis until formal documentation could be prepared and approved.

Robert Knecht, Assistant Administrator for Coastal Zone Management, becomes the Assistant Administrator for the new office, and Samuel Bleicher, Director of the Office of Ocean Management, becomes the Deputy Assistant Administrator.

Since the Office of Coastal Zone Management is a legislatively mandated name, the new office will still be called Office of Coastal Zone Management, although a revised name is expected when the Coastal Zone Management Act is reviewed by the Congress this fiscal year.

According to Frank, the merger was partly a result of the similarity of the activities of the two offices. "As these offices perform their functions," he said, "they found that interactions between them were frequent and important."

Some programs, he said, like the marine sanctuary and estuarine sanctuary programs, were already

working closely together. Finally, Frank added, the recent passage of the Outer Continental Shelf Lands Amendments, which give NOAA new responsibilities, led many to conclude that "now is the right time to establish a closer relationship between these two programs."

Aron Heads Marine Mammal, Endangered Species Unit

William Aron, former Director of the Office of Ecology and Environmental Conservation of the National Oceanic and Atmospheric Administration (NOAA), has become Director of the Office of Marine Mammals and Endangered Species in NOAA's National Marine Fisheries Service.

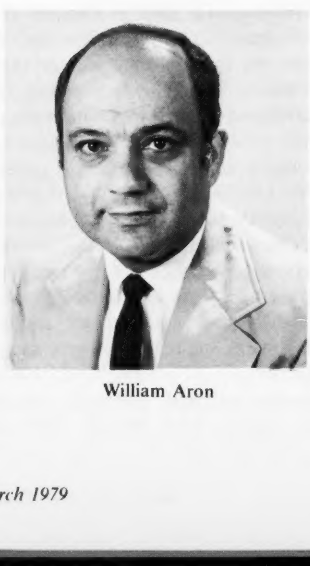
In his new post Aron has responsibility for coordinating the implementation of the Marine Mammal Protection and the Endangered Species Acts, both considered critical for the protection and conservation of animals of concern to many Americans.

Terry L. Leitzell, Assistant Administrator for Fisheries for NOAA, said Aron, who has worked for the past 7 years as NOAA's major adviser to the Administrator on conservation affairs, brings a broad biological and oceanographic background into the position.

Aron served in his previous position from 1971, working closely with conservation groups within and outside of government. He has served on the Scientific Committee of the International Whaling Commission on behalf of the U.S. Commissioner since 1972, and was the U.S. Commissioner to the International Whaling Commission in 1977.

Aron was Deputy Director of the Oceanography and Limnology Programs, Smithsonian Institution, from 1967 to 1971, and from 1961 to 1967 was Head of the Biological Oceanography Program for the GM Defense Research Laboratories. Between 1956 and 1961, he served as a Research Assistant Professor, Department of Oceanography, University of Washington.

Aron received his B.S. degree in Biology from Brooklyn College in 1952, his M.S. in Fisheries-Genetics in 1957, and his Ph.D. in Fisheries-Oceanography in 1960 from the University of Washington.



William Aron

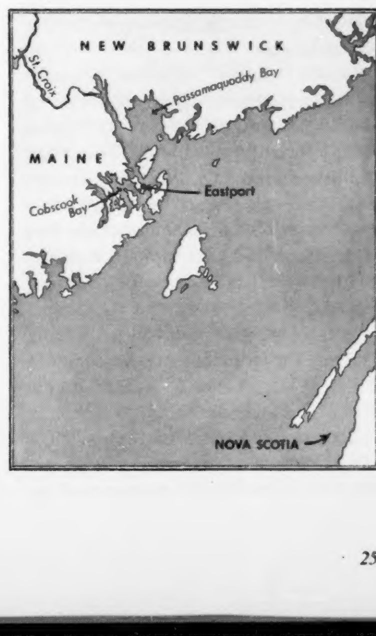
Pittston Refinery Could Hurt Northeast Fishing

A cold, foggy estuary that spawns some of the most important food fish on the U.S. eastern seaboard should not be the site of an oil refinery and marine terminal, the National Oceanic and Atmospheric Administration (NOAA) has said in a position statement to the Environmental Protection Agency. The adverse effects of an oil spill on the valuable commercial fishery for lobster, Atlantic herring, and other fish and shellfish could endanger these fisheries in northern Maine, Nova Scotia, and New Brunswick, as well as a large recreational fishery for Atlantic salmon, NOAA said in the statement.

The Pittston Company of New York has applied to EPA for a permit to contruct a 250,000-barrel-a-day oil refinery and associated marine terminal at Eastport, Me., on the St. Croix River estuary. Upon completion, it would receive crude oil transported by 80 million gallon carriers, and ship fuel oil and gasoline aboard small coastal tankers and barges.

A Canadian study of potential refinery sites along the east coast of North America terms the Passamaquoddy area "by far the least acceptable site evaluated, because of the recognized high value and vulnerability of its fisheries and aquatic bird resources, and the navigational hazards associated with tanker passage," the NOAA statement said. A U.S. interageny task force study, evaluating 69 sites from Maine to Florida, characterized the Eastport site as an alternative exhibiting severe and unacceptable risks to aquatic species and to commercial fisheries resources. Together the Canadian and U.S. studies considered 38 potential sites as environmentally superior alternatives, according to NOAA.

Eastport is on an island within the Cobscook Bay/Passamaquoddy Bay complex—a large, productive estuary on the U.S.-Canadian border. Tides average 18 feet and result in strong currents within narrow, winding channels and approaches to the proposed refinery site. Wind conditions are frequently severe, and the area experiences the highest frequency of "fog days" found along the U.S. east coast. The entire northern coastline of Maine is heavily indented with numerous bays, islands, peninsulas, rocky headlands, and submerged rocks or bars.



In the event of an oil spill, Cobscook Bay, Passamaquoddy Bay, and—depending on the size of the spill—portions of the Bay of Fundy and the Gulf of Maine could be affected, according to the NOAA position statement.

The unique combination of cold, nutrient-rich waters mixing in the coastal estuaries provide an ecosystem found nowhere else on the east coast of the United States. This area also provides food for oceanic species such as the endangered humpback, right, and fin whales as well as a number of other marine mammals, the NOAA statement said.

Congress' New Laws Affect NOAA, NMFS

Twenty-nine new laws of interest to NOAA and NMFS were enacted during the 95th Congress, 2nd Session (calendar year 1978), including several amendments to existing laws. Those most applicable to marine resources are outlined below. If specific information concerning a law is desired, a copy of the law should be obtained.

Merchant Marine Act Amendment (H.R. 9169), 7 April 1978, Public Law 95-257. This law amends Title XI of the Merchant Marine Act of 1936 to authorize the Secretary of Commerce to guarantee obligations up to 87 percent of the cost of constructing or reconstrcting fishing vessels.

National Ocean Pollution Research and Development and Monitoring Planning Act of 1978 (S. 1617), 8 May 1978, Public Law 95-273. This established a program of ocean pollution research, development, and monitoring; designating NOAA, in consultation with the Office of Science and Technology Policy, as the lead agency for pollution research.

Central, Western, and South Pacific Fisheries Development Act Amendment (H.R. 11657), 16 June 1978, Public Law 95-295. This amends the Act to authorize the Secretary of Commerce to carry out a program for the development of the tuna and other latent fisheries resources of the central, western, and south Pacific Ocean in conjunction with the Pacific Tuna Development Foundation or some other proposed agency or organization.

NACOA Appropration for Fiscal Year 1979 (H.R. 10823), 29 June 1978, Public Law 95-304. This amended the Act of 5 July 1977 and authorized appropriations for the fiscal year ending 20 September 1979.

Fishery Conservation Zone Transition Act Amendment (H.R. 12571), 1 July 1978, Public Law 95-314. Various requirements of the Fishery Conservation and Management Act of 1976 were waived to permit fishermen of the United States and Canada to continue fishing off the coasts of each nation during the period ending 31 December 1978.

Marine Mammal Protection Act Amendment (H.R. 10730), 10 July 1978, Public Law 95-316. This authorized appropriations for the Department of the Interior, the Department of Commerce, and the Marine Mammal Commission to carry out the Marine Mammal Protection Act of 1972.

North Pacific Fisheries Act Amendments (H.R. 21637), 28 July 1978, Public Law 95-326, and (S. 3551), 30 October 1978, Public Law 95-553. P.L. 95-326 amends the North Pacific Fisheries Act of 1954 to implement the Protocol Amending the International Convention for the High Seas Fisheries of the North Pacific Ocean (INPFC), signed 25 April 1978. P.L. 95-553 makes minor technical amendments to P.L. 95-326.

Agricultural Credit Act of 1978 (H.R. 11504), 4 August 1978, Public Law 95-334. The act, among other things, amends the Consolidated Farm and Rural Development Act to require the Secretary of Agriculture to make emergency loans to applicants where the Secretary finds the applicant's farming, ranching, or aquaculture operations have been substantially affected by a natural disaster in the United States or by a major disaster or emergency designated by the President under the Disaster Relief Act.

Fishery Conservation and Management Act Amendments/Joint Ventures (H.R. 10732), 28 August 1978, Public Law 95-354. This law authorizes $30 million for administration of the Fishery Conservation and Management Act of 1976 (FCMA) for fiscal year 1979. It also authorizes the Secretary of Commerce to regulate foreign processing vessels that receive fish from U.S. fishing vessels within the fishery conservation zone by limiting the issuance of permits to foreign processing vessels to those fisheries that will not be utilized by U.S. fish processors.

Outer Continental Shelf Lands Act Amendment of 1978 (S. 9), 18 September 1978, Public Law 95-372. This law requires the establishment of a policy for the management of oil and natural gas resources of the Outer Continental Shelf in order to provide for rational development of these resources of the OCS and to protect the marine and coastal environment.

Fishermen's Protective Act Amendments (H.R. 10878), 18 September 1978, Public Law 95-376. This extends the insurance program carried out pursuant to section 7 until 1 October 1981; revises the program of compensation in section 10 for American fishermen who lose or have fishing gear damaged as a result of foreign fishing activities in the U.S. fisheries zone; and provides additional protection to endangered or threatened species of fish and wildife.

Farm Credit Act Amendment (S. 3045), 10 October 1978, Public Law 95-443. This amends the Farm Credit Act of 1971 to extend the maximum term for production credit association loans to producers or harvesters of aquatic products from 7 to 15 years.

Anadromous Fish Conservation Act Amendments (S. 415), 17 October 1978, Public Law 95-464. This broadens the scope of the conservation program authorized by the Anadromous Fish Conservation Act to include landlocked anadromous fisheries in Lake Champlain.

Port and Tanker Safety Act of 1978 (S. 682), 17 October 1978, Public Law 95-474. This amends the 1972 Ports and Waterways Safety Act to establish improved Federal standards governing navigation and vessel safety and the protection of the marine environment.

Antarctic Fauna and Flora Conservation (H.R. 7749), 28 October 1978, Public Law 95-541. This Act

directs the Director of the National Science Foundation to establish a permit and regulatory system to control: 1) The taking of animals and plants native to Antarctica; 2) the introduction of nonnative species into Antarctica; 3) the disposal of pollutants in Antarctica; and 4) the activities of the United States citizens in certain areas of Antarctica. Also, the Act amends the Fishermen's Protective Act to clarify that a vessel's documentation or certification under U.S. laws would not be affected if commanded by a person other than a citizen of the United States during any fishing voyage beyond the U.S. fishery conservation zone. This amendment was retroactive to 1 January 1978.

Federal Water Pollution Control Act Amendments (H.R. 12140), 2 November 1978, Public Law 95-576. This Act is an authorization for appropriations for certain water pollution control programs of EPA.

Fish and Wildlife Improvement Act (H.R. 2329), 8 November 1978, Public Law 95-616. Among other things, the Act authorizes the Secretaries of Commerce and the Interior to enter into formal cooperative agreements with states and other Federal agencies for enforcing fish and wildlife laws and to establish and conduct programs to train personnel in enforcement matters.

Endangered Species Act Amendment (S. 2899), November 1978, Public Law 95-632. This amends the Endangered Species Act by establishing a review procedure and an interagency committee to resolve conflicts between endangered and threatened species and actions of Federal agencies, and to determine mitigation and enhancement measures to conserve endangered and threatened species.

Fish Egg Chromosome Divisions Sensitive to Contact With Oil

After being spawned, the buoyant eggs of many valuable marine fishes float to the surface of the sea where they remain until hatching. The thin surface layer in which they are found is subject to pollution from the atmosphere, runoff from the land, and oil spills, and retains and concentrates materials and chemicals that are specifically toxic to dividing cells and that may cause deadly changes in chromosomes.

Selected fish eggs taken from Nantucket Shoals waters after the *Argo Merchant* oil spill, some dead and some dying, were found to contain arrested and abnormal chromosome divisions probably caused by pollutants. There is mounting evidence that oil is toxic to the eggs and larvae of some fish, especially in the early, fragile stages, but the absence of baseline information on normal development of fish eggs in relatively clean waters and their natural mortality does not permit a full assessment.

The normal development of cells of any species (mitosis) begins with the precise division of the combined chromosomes of the male gamete (sperm) and female gamete (egg). The embryo must have a balanced set of chromosomes for normal development to occur. Environmental influences that upset this balance may cause abnormal or arrested development as the cells multiply, and death is usually the end result. Therefore, abnormalities in the chromosome makeup during the early embryo stage are probably the most sensitive, practical indicators of the effects of marine pollutants on reproduction in fish.

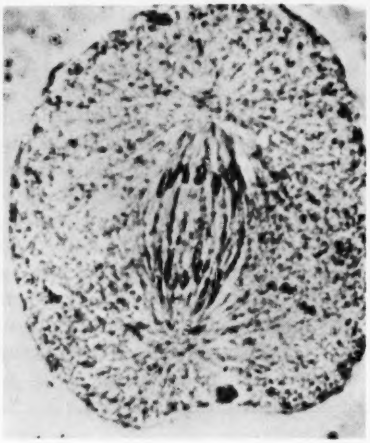
Crude and refined oils have many compounds, some of which are soluble in lipid materials (fatty substances) present in fish eggs. Benzene and polynuclear aromatic hydrocarbons (having an odor) can change the hereditary material, and cause the development of tumors and malignant growths. These compounds of oil appear to alter the surface properties of cell membranes; however, paraffin hydrocarbons do not. Dividing cells that develop into male and female reproductive cells of some fish are particularly susceptible to abnormal chromosome separation, and to mutations in the genes.

A new methodology for the study of chromosomes and their divisions in fish eggs sorted from plankton collected at sea was developed whereby the eggs of certain marine fishes are identified by species and then separated according to their developmental stages. The embryos are dissected from the eggs, their cells flattened into monolayers, and their dividing chromosomes viewed under high-resolution, high-power, light microscope optics. At their most sensitive stages, most eggs of Atlantic mackerel from the heavily polluted New York Bight did not survive (Longwell, 1976).

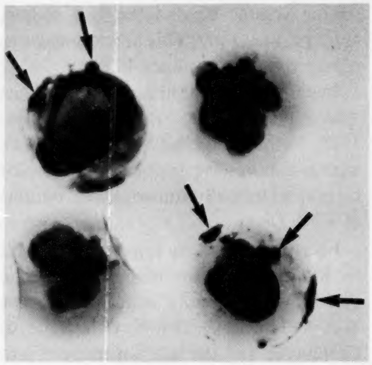
A. Crosby Longwell, a biologist and geneticist of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), working in NOAA's National Marine Fisheries Service, Northeast Center, Milford Laboratory, in Milford, Conn., and colleagues have worked together in investigating the ways petroleum hydrocarbons affected the development of fish eggs in oil-polluted waters after the *Argo Merchant* spill on Nantucket Shoals, December 1976[1]. Longwell concludes that there is mounting evidence that oil is toxic to fish eggs and larvae, and may be lethal to, or adversely affect, their normal cellular division. However, this researcher cautions that not enough is yet known about whether factors in clean, unpolluted marine water may also limit normal division. More baseline data are needed for meaningful and significant comparisons to be made.

Cod and pollock eggs were taken from surface waters near the *Argo Merchant* oil spill (December 1976) and examined for oil. About 80 percent of the tanker's cargo was No. 6 fuel oil, which formed "pancakes" that remained on the surface and increased in size with time. The remaining 20 percent (No. 2 oil) was a less viscous but more toxic fuel, which had concentrations of up to about 250 parts per billion (ppb). Maximum concentrations were from 1.8 to 3.6 m (5.9 to 11.8 feet) below the pancake slicks.

[1]Longwell, A. Crosby. 1977. A genetic look at fish eggs and oil. *Oceanus* 20(4):46-58.



This photomicrograph shows an embryo dissected from a planktonic mackerel egg after its first division (mitosis) into two cells. It is this telophase (final stage of mitosis) that is used to appraise chromosome breakage, irregular distribution of chromosomes, and other physiological disturbances to the cell and chromosome division process.



These pollock eggs, in the tail-bud and tail-free embryo stages, were sampled at the edge of the *Argo Merchant* oil slick. The eggs at upper left and lower right have outer membranes contaminated with oil (arrows). The uncontaminated egg at upper right has a malformed embryo, and that at lower left is collapsed and also has a malformed embryo.

Chromosomes of an Atlantic mackerel egg sampled from ocean survace waters.

All samples taken at a number of stations within and adjacent to the floating slicks showed some contamination. About half of all the fish eggs examined had oil droplets and tar adhering to their outer membranes (chorions). Fewer cod eggs were fouled than those of pollock.

To determine the effects of the oil and tar on the chromosomes and their divisions as they affect cell heredity of the developing embryo, the new methodology was applied to a study of the field-exposed eggs (79 cod and 162 pollock) sampled near the *Argo Merchant* oil spill. Also examined were 75 uncontaminated cod embryos from aquarium-held fish.

About 20 percent of the cod eggs and 46 percent of the pollock eggs collected at sea were dead or dying with their chromosome divisions arrested. Only 4 percent of the uncontaminated cod eggs from the laboratory aquarium were dead or dying with arrested divisions. Some pollock embryos from stations near the slicks were grossly malformed; none were malformed in samples taken at distant locations. Also, the hatched larvae of the six different species of fish sampled near the *Argo Merchant* spill were less prevalent within the area of the slicks than at points further removed. However, the absence of baselines for purposes of comparison makes it impossible to assess fully the significance of the cod and pollock findings from the *Argo Merchant* spill area.

In the same light, no laboratory studies have been made of the effects of oil on the chromosome divisions of developing fish embryos. However, it has been shown (Kühnhold, 1972) that cod eggs in a hatchery were most sensitive to the effects of some crude oil extracts during the first few hours after fertilization. Development was retarded and, in some instances, hatching was delayed or did not occur. Most of the hatched young were abnormally developed, swam erratically, and died after a few days.

Other researchers have shown that eggs of turbot, plaice, anchovy, scorpionfish, and sea parrot are adversely affected by concentrations of around 1 part per million or lower, of oil in water (Mironov, 1968, 1969, 1972). It was found (Struhsaker et al., 1974) that the development of abnormal embryos was the principal effect of benzene, a water-soluble component of crude oil, on the eggs of Pacific herring.

Apparently, damage to the zygote (united reproductive cells) at the chromosome and cellular levels occurs when early stage fish eggs are exposed to oil and oil fractions. Until this study, planktonic fish eggs have not been examined with respect to their chromosomes and their division configurations.

Thus, classical genetics provides some explanations on the mortality of fish eggs, and can be a means of monitoring this most fragile link in the life cycle of fishes in their natural habitat. Yet, a fuller understanding of the natural mortality of fish eggs and larvae is needed before the effects of marine pollution on the reproductive cycles of fishes can be fully understood.

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New International Whaling Quotas Set

The International Whaling Commission agreed in late December to eliminate sperm whaling completely in one area of the southern hemisphere and also voted to reduce sperm whale quotas drastically in the north Pacific.

Calling the results of the two-day meeting in Tokyo "a significant victory," Richard A. Frank, U.S. Commissioner to the IWC and Administrator of the National Oceanic and Atmospheric Administration, stated: "We are pleased that the Commission has acted vigorously to curb whaling for sperm whales. The United States would have preferred and strongly urged a complete elimination this year of sperm whaling in the North Pacific. However, we believe that the substantial reduction voted by the Commission will mean the end of pelagic whaling in this region by Japan."

In 1978, sperm whale quotas were set at 561 for Division 5 of the southern hemisphere (an area from the equator to the Antarctic, and long. 90° E to long. 130° E), and at 6,444 in the north Pacific. The Commission's action set a moratorium on whaling in Division 5 and reduced north Pacific quota to 3,800 for 1979, a cut of more than 40 percent. The Commission further established a zero quota for female sperm whales in the north Pacific, although it did allow an accidental catch of slightly more than 400 females to be counted against the total quota.

The Commission also passed two strongly worded resolutions introduced by the United States, calling for a prohibition of trade in whale products and implementation by the member and nonmember nations. "If fully adhered to," Frank predicted, "these resolutions will go a long way toward bringing all whaling operations under effective international regulations."

Frank expressed caution and optimism about the possibility of future conservation gain in the Whaling Commission: "The progressive reduction in quotas is encouraging. Progress in the Commission to achieve a total moratorium on whaling is not as fast as we would like, but the Commission is continuing to move in the right direction for reducing quotas, as thus providing better protection for the great whales.

Steps Taken To Protect Sea Turtles in Florida

Emergency fishing regulations designed to protect turtles hibernating in the Port Canaveral Navigation Channel, Cape Canaveral, Fla., were published in late November by the National Oceanic and Atmospheric Administration (NOAA).

The Commerce Department agency's National Marine Fisheries Service, in the regulations, prohibited fishermen from using trawl gear in the channel waters until 19 March when the emergency regulations expire. It is believed loggerhead and Kemp's ridley sea turtles hibernate there between November and March. Public hearings were also scheduled to determine whether the regulations should be modified or extended.

The emergency regulations followed reports that last year shrimp vessels had captured large numbers of loggerhead sea turtles incidental to trawling in the channel. A survey by the NMFS in February and March 1978 confirmed the presence of the hibernating turtles, and additional surveys are now being conducted to obtain more information on them. The turtles are protected by the Endangered Species Act of 1973.

Under the regulations, trawling was prohibited in those parts of the channel known as the middle basin, east basin, inner reach, and that part of the dredged channel beyond the outer reach to a point 1.5 nautical miles beyond buoys "R 7" and "R 8."

Dieldrin, Endrin Levels "Very Low" in Fish off Southeast U.S. Coasts

An analytical study completed recently by the Utilization Research Division, NMFS Northwest and Alaska Fisheries Center, Seattle, Wash., showed that the dieldrin and endrin content of three species of fish, red snapper, king mackerel, and Spanish mackerel, caught off the southeastern coasts of the United Staes was very low. The data constitute part of a survey by the Utilization Research Division of chlorinated hydrocarbon residues in the edible tissue of fish from the Atlantic Ocean and Gulf of Mexico.

Although the three species were previously determined to have the highest DDT and PCB levels of six species analyzed, only one-third of the 46 samples of snapper mackerel contained quantifiable amounts of either dieldrin or endrin. The highest level was 0.026 ppm, less than one-tenth of the FDA tolerance of 0.3 ppm. The details are tabulated below.

Dieldrin and endrin in fish from the southeastern U.S. coast.

		Dieldrin (ppm)		Endrin (ppm)	
Species	No.[1]	Mean	Range	Mean	Range
Red snapper	18	n.d.[2]	n.d.-0.002	n.d.	n.d.-0.003
King mackerel	18	0.005	n.d.-0.026	0.004	n.d.-0.014
Spanish mackerel	10	0.007	n.d.-0.014	0.008	n.d.-0.026

[1]Number of composites, each consisting of 10 fish.
[2]n.d.=none detected.

Scientists Seek Food From Saltwater Plants

Sea Grant scientists at the University of Delaware are attempting to produce edible plants that will grow in saltwater

with the potential of becoming a food crop. The investigation—one of several supported by a $890,000 Sea Grant from the National Oceanic and Atmospheric Administration (NOAA)—is focusing on halophytes, grass-like plants that grow naturally in salty soils. Initial efforts are pointed towards identifying which halophyte species produce large and abundant seeds, and have the potential for managed production. The Commerce Department agency grant is being supplemented by $701,100 in non-Federal funds.

Other Sea Grant researchers at the University are testing a small, simple system to use sea wave energy in converting saltwater to fresh. Preliminary estimates suggest the cost would be only slightly greater than that most suburban U.S. homeowners pay for water.

Under NOAA grants, Delaware scientists and engineers have designed a unique, controlled mariculture system for growing oysters and clams, and hope to grow oysters to market size in less than a year, compared with 3 years in the wild. Maricultured clams also grow to market size significantly faster than do wild clams.

Prince William Sound Ecosystem Study Starts

National Oceanic and Atmospheric Administration (NOAA) scientists have begun an ecosystem study of Alaska's Prince William Sound to give environmental managers information needed to anticipate and ease the ecological pressures created by North Slope oil shipping and expanded commercial development in the area.

Initially funded by NOAA and the Environmental Protection Agency, the project is expected to last about 5 years. Field work deals initially with understanding and minimizing the probable environmental impacts of oil spills in the area.

"What makes this study unique is that we're able to begin it at a stage of minimal human impact," NOAA Corps Lieutenant Christine S. Carty, acting manager of the Anchorage-based project, explained. This means there is a good chance for the Sound's beauty and vitality to be preserved, she said. Continuing development of the natural resources of Alaska and the Sound promises to build up the sparsely populated area of Alaska's south coast, although the rate of economic growth is difficult to predict, according to Carty.

The Prince William Sound effort is the third major coastal study undertaken by the Marine Ecosystems Analysis (MESA) Program, part of NOAA's Environmental Research Laboratories in Boulder, Colo. The other two focus on Puget Sound and on the ocean area off the New York-New Jersey coast.

Marine Recreational Angling Survey Begun

The National Oceanic and Atmospheric Administration has awarded contracts totaling $1.3 million to Human Sciences Research, Inc., McLean, Va., and Clapp and Mayne, Inc., San Juan, Puerto Rico, to collect data on the fish catch by marine recreational anglers. The survey is being conducted for the National Marine Fisheries Service.

The recreational fishery statistical survey will be done on the Atlantic and Gulf coasts, Hawaii, Guam, American Samoa, Alaska, Puerto Rico, and the Virgin Islands. The results of the survey, to be conducted between 1 November 1978, and 31 October 1979, will be available in February 1980. The Virginia firm was awarded a $1,192,404 contract, while the San Juan company's contract was for $117,924.

The survey will provide estimates of participation, catch, and effort by marine recreational anglers for each geographical region and State in the survey. Included will be information on finfish and selected shellfish by species, by State or region, the number of marine anglers, number and length of fishing trips, number of days spent fishing, total catch by weight and numbers, method of fishing used and what the anglers did with their catch. The information obtained during the survey will be used in the development of fishery management plans by the Regional Fishery Management Councils.

Canadian Fishermen Have "Excellent Year" in 1978

Fisheries and Oceans Minister Romeo LeBlanc released Canada's sea fisheries catch and landed value statistics for the first 9 months of 1978 which, compared with the same period in 1977, indicate an excellent year for Canadian fishermen. Sea fish catch until the end of September 1978 for both Atlantic and Pacific coasts totalled 895,647 metric tons (t) valued at $448,943,000, according to the Fisheries and Oceans report.

"I am extremely happy with this general improvement in the sea fisheries, and hope that this trend will continue throughout 1978 and into 1979," said LeBlanc.

On the Atlantic Coast the total fish catch for the first nine months of 1978 was up 21 percent over the 1977 figure for the same period, and the landed value was up 49 percent. Figures for the Pacific Coast indicate an overall decline of seven percent from 1977 landings, due mainly to the lower abundance of shrimp and herring, but reflected an increased value of 44 percent.

Atlantic Coast

The total catch at the end of September 1978 amounted to 744,545 t with a landed value of $263,417,000, compared with the 1977 statistics of 615,912 t valued at $177,190,000.

Pacific Coast

On the Pacific Coast the total catch for the first 9 months of 1978 amounted to 151,102 t valued at $185,526,000. For the same period in 1977 the figures were 162,627 t valued at $128,939,000. More complete details on catch and value statistics are provided in the accompanying table or are available from the Intelligence Services Division, Marketing Services Branch, Fisheries and Oceans, Ottawa, Ontario, Canada, K1A OE6.

Canada's marine fish catch, January-September 1977 and 1978, based on preliminary estimates.

Species/area	Landings (t)		Percent increase or decrease	Values ($1,000)		Percent increase
	1977	1978		1977	1978	
Atlantic						
Groundfish	346,135	452,376	31	$ 80,127	$116,669	46
Cod:Maritimes	44,960	57,086	27	$ 12,205	$ 17,382	42
Quebec	19,708	27,948	42	$ 5,662	$ 8,577	51
Newfoundland	96,468	151,382	57	$ 22,824	$ 40,201	76
Redfish	42,121	51,217	22	$ 6,130	$ 8,491	39
Flatfish	80,843	77,527	-4	$ 16,929	$ 17,276	2
Herring:Maritimes	96,017	72,928	-24	$ 9,737	$ 11,591	19
Newfoundland	34,330	31,688	-8	$ 3,186	$ 5,145	61
Quebec	3,948	5,404	37	$ 485	$ 901	86
Total Atlantic	615,912	744,545	21	$177,190	$263,417	49
Pacific						
Groundfish	19,982	19,930	0	$ 14,497	$ 22,178	53
Salmon	53,996	54,625	1	$ 84,731	$110,951	31
Herring	81,575	66,708	-18	$ 25,313	$ 46,573	84
Shellfish	4,562	4,268	-6	$ 3,658	$ 4,881	33
Total Pacific	162,627	151,102	-7	$128,939	$185,526	44

Japan Expects High 1978 Fishery Product Imports

Japan's imports of edible fishery products, particularly those of salmon, shrimp, and squid, were expected to register new historical highs in 1978, according to a leading fishery newspaper in Tokyo. Imports of salmon totaling 20,400 metric tons (t) to August 1978, twice the amount to the same month in 1977, eclipsed a 1977 total import. To August 1978, imports of shrimp totaled 89,000 t (19 percent above 1977 to August), those of squid 67,000 t (53 percent), and those of octopus 53,000 t (42 percent above).

Also increasing at a pace ahead of 1977 were the imports of sea bream and spiny lobster. Imports of Spanish mackerel and hairtail from South Korea were also reported on the rise. The sharp increase in the imports of edible fishery products in 1978, occurring in spite of the stagnation of domestic consumption, was attributed to the high value of the yen and the concern among the importers over the future supply of these products from foreign 200-mile zones, according to the newspaper. (Source: FFIR 78-14).

Japanese, Mexican Firms In Joint Fishery Venture

Two major Japanese firms, Nichiro Fisheries Company[1] and C. Itoh and Company, as of 5 October, formed a fishery joint venture with a Mexican firm Valores Industriales S.A., a principal firm under one of Mexico's largest conglomerates, Monterrey Group, with businesses in beer, fertilizer, cannery, real estate, and financing. The joint venture, named Abisal, is said to be the first of its kind to be formed under the 1977-1982 National Fishery Development Program of Mexico with participation of a Japanese firm.

The paid capital of the joint venture, is 11,600,000 pesos (aproximately 100 million or US$0.55 million). Valores

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Industriales S.A. holds 51 percent of the stocks in the joint venture, with the remaining 49 percent held in equal shares of 24.5 percent each by Nichiro and C. Itoh. The joint venture, to be headed by five Mexican and four Japanese officers under a Mexican chief executive officer, will have its main office in Monterrey, Baja California, and will conduct its fishery operations from the base at Ensenada.

The joint venture planned to begin fishing for black cod in December 1978 in waters off Baja California where it reportedly had discovered a promising fishing ground for this fish. Initial catch target was said to be 1,500 t using one vessel to be chartered from Nichiro, but the operations will employ five vessels 3 years later aiming to catch approximately 15 percent of Japan's annual demand for black cod totaling between 40,000 and 50,000 t. The joint venture is believed to be hopeful to expand its fishing operations not only for squid and tuna within Mexico's 200-mile waters, but also in the U.S. 200-mile zone where Mexico is allowed catch quotas for Alaska pollock, hake, and squid. (Source: FFIR 78-14).

JAPAN PLANS TO CATCH MORE KRILL

The Japanese efforts to harvest krill during the 1978-79 Antarctic summer were planned to be the largest since the annual efforts began 4 years ago. A total of 21 fishing vessels were to participate in the harvesting that lasts about 3 months beginning December 1978. Additionally, several refrigerated transports were to be employed to carry the products to Japan. The total catch is expected to exceed 40,000 t. Table 1 shows the Japanese krill fishery plans for the 1978-79 Antarctic season.

Japan caught 4,500 t of krill during the 1975-76 season in its first attempt at commercial krill fishing. In 1976-77, the catch jumped to 11,500 t, and in 1977-78, it nearly doubled to 21,000 t. Although the endeavors are commercial in scale, they have not yielded profits.

During the 1977-78 season, 18 vessels engaged in harvesting, and they processed the catch into four types of products: Fresh frozen (whole); boiled and frozen (whole); peeled, boiled, and frozen; and dried (whole). In Japan these products have been selling well, except the boiled frozen whole krill.

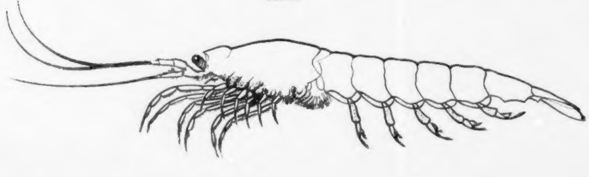
That product has been repacked in Japan for the general consumer market. The present retail sales of the repacks are 50 percent below the 1977 level, owing to the extensive consumer apathy towards the prices of fish in general. If the sales do not improve, a 5,000 t inventory surplus of this commodity will exist when the products made from the new crop appear at the markets.

Krill producers estimate that about 60 percent of this season's catch will be processed into animal and aquaculture fish feeds. The remainder will become various processed food. The feed use is well established, but, the food use needs more innovative sales promotions. (Source: LSD 78-19).

Table 1.—Japanese krill harvesting plan for the 1978-79 season.

Organization	No. of vessels: Large trawlers	Medium trawlers	Mother-ship	Production target (t)
Hoko Suisan Company	1			1,500
Japan Marine Research Center	1	10	1	17,214
Kyokuyo Gyogyo Company	1			2,000
Nichiro Gyogyo Company	2			3,656
Nippon Suisan Company	2			10,120
Taiyo Gyogyo Company	3			7,150
Total	10	10	1	41,640

Krill



Quality and Price Key to Japan's Fish Consumption

Future consumption of fishery products among Japanese consumers would depend upon the quality as well as the price of the products, according to an analysis released last fall by a leading fishery trade journal in Tokyo.

During a 5-year period up to 1976, the spending by an average Japanese family on seafood products approximately doubled although the amount of fresh and frozen seafood consumption remained about constant. This was attributed to the fact that the consumers increasingly sought high quality and gourmet products in proportion to the rising income.

This pattern saw a rude disruption in 1977 when the consumers reacted to speculative high prices of fish products with what was termed as "fish alienation." For instance, during the first 6 months of 1977 alone, the prices of seafood rose as much as 25-30 percent, as compared to the normal annual rise of 10-15 percent, and the consumption of fresh and frozen seafood by an average family declined to 56.5 kg for the year, down 6.1 percent from the previous year.

Predictably, the decline was particularly severe for high priced products such as sole, salmon, jack mackerel, Alaska pollock, and saury. In 1978, the low prices of high quality tuna were said to be luring back some of the alienated consumers to seafood products. (Source: FFIR 78-13).

Stable Japan Market Seen for Air-Shipped Bluefins

In 1972, Japanese fish traders shipped 60 t of giant bluefin tuna from the northeastern parts of the United States to Tokyo by air freight. This was the beginning of the commercial scale air-freighting of the frozen tuna intended for the Japanese sashimi and sushi (or, raw) use, according to the NMFS Language Services Branch, International Fisheries Development and Service Division. Seven years later, in 1978, the volume has increased to nearly 1,000 t, and the demands for the "jumbo" tuna, so-called by the Japanese traders, is stable.

The headed and gutted frozen tuna begins its journey to Japan from Logan Airport, Boston, or Kennedy Airport, New York. The average weight of the fish in this form is 300 kg. They consist of catches from a widely stretching coastal area between New Brunswick, Canada and New Jersey. Moreover, the bluefins have been caught by a variety of methods by several categories of fishermen.

More than a half of these giant fish come from the catches of U.S. sport fishermen. The remainder come from the catches of eastern Canadian sport fishermen; from the purse-seining catches of Massachusetts; and from ocean ranching in Margaret's Bay, Nova Scotia, Canada. The ranching operation fattens up the bluefins that are incidentally caught in the local mackerel setnets. These fish are found in the nets in June and July, as they have migrated northward after spawning. They are too lean for the Japanese raw fish market, but 2-3 months feeding in a special net pen fattens them to the exportable level.

The purse seiners are based in Sandwich, Mass. Three vessels participate in this operation, each having a 180 t allocation a year. The Marubeni Trading and the Nichiro Fisheries Companies jointly deal with the American owners of the two of the vessels, and the Satake Company deals with the owner of the remaining one. Table 1 shows the number of air-freighted bluefin tuna by year and by fishery.

Table 1.—Number of air-freighted bluefin tuna[1] by fishery and by year.

Fishery	Prospect for 1978	[1]1977	[2]1976
U.S. sport catch	1,800	1,650	1,500
Canadian sport catch	450	750	650
Purse seining off Mass.	400	500	500
Ocean ranching	450	700	350
Total	3,100	3,600	3,000

[1]To obtain the volume multiply the number by 300 kg, which is the weight of the average headed and gutted bluefin tuna air-freighted.
[2]Estimates.

The exvessel prices of the sport fishermen-caught bluefins have risen from US$0.30-0.40/pound in 1972 to US$0.70-1.85/pound in 1978. The wholesale price of the commodity fluctuates seasonally, reaching a high usually after the summer. Table 2 shows the prices of the air-freighted bluefin tuna at the Toyko Central Fish Market.

The "jumbos" are distributed at several other central markets, including the ones at Sapporo, Hokkaido; Sendai, Miyagi Prefecture; and Kyoto, Osaka and Kobe in western Japan. The wholesale prices at those regional centers are only slightly higher than in Tokyo. (Source: LSD 78-19).

Table 2.—Average Tokyo wholesale price of air-freighted bluefins by month and year.

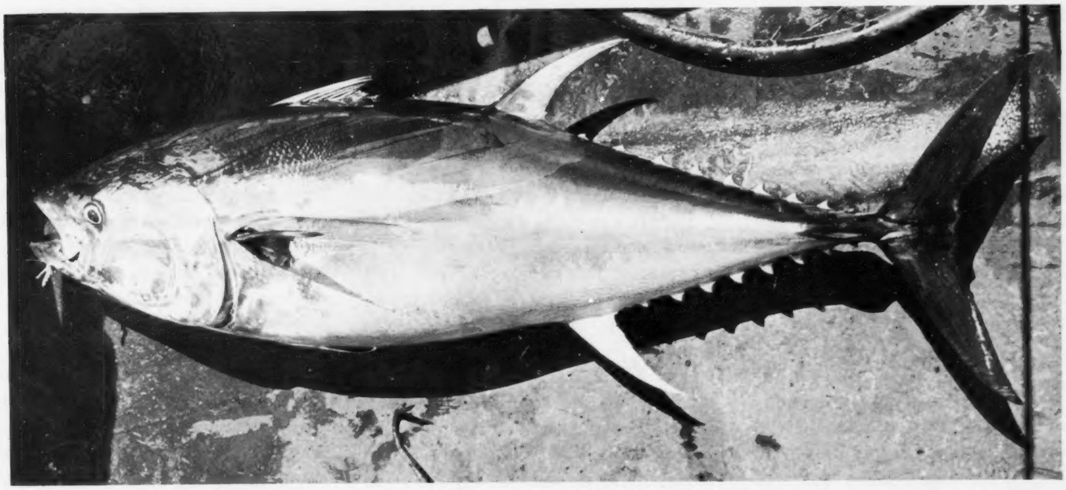
Month	1978 Yen/kg	1978 US$/lb[1]	1977 Yen/kg	1977 US$/lb[2]
July	1,820	4.17	1,100	1.85
August	1,990	4.52	1,900	3.20
September	2,450	5.57	2,300	3.87

[1]@200 Yen=US$1.00
[2]@270 Yen=US $1.00

Bluefin Tuna Corral Culture Progress Noted

A prototype experiment aiming to raise bluefin tuna in an artificial corral, currently in the second year of the project off the Sukumo Bay, Kochi Prefecture,

Bluefin tuna



Japan, has reportedly succeeded in attaining the initial objective: To raise a young fish to an adult.

A group of about 400 baby fish, which were placed in the corral in July 1978, are reported to have grown to an average size of 700 g each from the initial 150-200 g within 3 months. Five surviving fish from the group which entered the corral in 1977, reportedly weighed 5-6 kg each by fall 1978 and were expected to grow to a weight of about 10 kg by the end of 1978.

According to Japan's Fishery Agency, sponsor of the project, the success thus far is attributed to: 1) The improved methods of switching the corral in accordance with the growth in fish size, 2) the high dissolved-oxygen content and the clean water available in the offshore corral, and 3) establishment of a method to safeguard the fish from predators such as shark. (Source: FFIR 78-14).

CANADA'S 1979 SEAL HUNT QUOTA STATIC

Following national and international consultations on the status of seals, Fisheries Minister Roméo LeBlanc announced the 1979 quotas for the east coast seal hunt late last year. The total regulated catch of harp seals in 1979 will remain at the 1978 level of 170,000 not including an expected catch of 10,000 by indigenous peoples of Greenland, the Canadian Arctic and Labrador.

In announcing the catch limits the Minister noted that the scientists have advised that the current population of harp seals could sustain a catch of 214,000-240,000. Canada and the European Economic Community, on behalf of Denmark/Greenland have agreed on a policy of restricting catches to lower levels in order to allow the population to grow from its present level of 1.3-1.4 million animals 1 year of age and older to 1.6 million. At the present rate of population growth this level is expected to be reached in 5-10 years.

Canada's share of the catch will be increased from 135,000 in 1978 to 150,000 in 1979, while Norway's share is reduced from 35,000 to 20,000. The additional Canadian allocations will be taken by land-based sealers and the allocation to Canadian large vessels at the Front ice fields northeast of Newfoundland and Labrador will remain at the 1978 level of 57,000.

The official opening and closing dates were set for 10 March and 24 April but the Minister indicated that the opening date could be varied slightly depending upon conditions at the time. The hooded seal season was scheduled to open 8 days after the harp seal opening date, subject again to possible slight variation, but not later than 19 March. The total Allowable Catch for 1979 remains at 15,000. It was agreed that a quota of 6,000 be allocated to Norway and that the Canadian fleet would take up to 6,000 by 26 March. On that date the balance of 3,000 was to be made available to vessels of either country.

An important conservation measure adopted for 1977 was that the kill of adult female hooded seals would be restricted to 10 percent of the total catch. This measure was further strengthened for 1978 when the limit was reduced to 7.5 percent of the total catch. For 1979 the limit was further reduced to 5 percent. The scientists have determined that the management regime for hooded seals will also allow this population to increase.

Preliminary statistics indicate that the 1978 catch of harp seals at the Front and Gulf of St. Lawrence was 161,100, including 16,254 taken by Norway, while that of the hooded seals was 10,200, including 6,315 taken by Norway.

Canadian Heads FAO Fisheries Department

Kenneth C. Lucas, Senior Assistant Deputy Minister in the Fisheries and Marine Service of Canada's Department of Fisheries and the Environment, has been named Assistant Director-General in charge of the Food and Agriculture Organization's Fisheries Department. The appointment of Lucas was announced in Rome by FAO Director-General Edouard Saouma.

Lucas has been responsible, since 1973, for establishing and managing the Fisheries and Marine Program of the Canadian Department of Fisheries and the Environment. The scope of the program included management of Canada's ocean and inland fisheries and conduct of fisheries and oceanographic research, contributing to the understanding and optimum use of renewable aquatic resources and marine waters. The Fisheries and Marine Service engages in hydrographic surveying and charting of navigable coastal and inland waters and manages 2,400 fishing and recreational harbors. Lucas also supervised environmental impact studies of developments affecting coastal and inland waters and living aquatic resources. He engaged in the negotiation and administration of 30 international treaties and agreements.

Lucas was born 8 June 1929 in Vancouver, British Columbia, and was educated in British Columbia. In 1952, he received a Bachelor of Science Degree in Civil Engineering from the University of British Columbia. In 1956, he obtained the Registration Certificate of the Association of Professional Engineers of British Columbia.

Norway's Cod and Capelin Quotas Reduced for 1979

The distribution and the regulation of the capelin and Norwegian-Arctic cod quotas in the Barents Sea were the central issues for discussion at the 5-day meeting of the Norwegian-Soviet Fishery Commission held in Oslo between 30 October and 3 November 1978, reports the Norwegian Information Service (Norinform).

As a consequence of the negotiations, the decision was taken to reduce the total quotas for catches of capelin and Norwegian-Arctic cod in 1979. The total quota for capelin has been fixed at 1.8 million tons and the Norwegian share is stipulated at 60 percent and not 75 percent as originally requested by Norway. Soviet vessels will fish the residual amount. The cod quota is to be reduced by 150,000 t to 660,000 t, and this quota will be divided equally between Norway and the Soviet Union after 90,000 t has been allocated to third countries. Of this latter amount, 15,000 t

will be fished in the Svalbard zone, 45,000 t in the Norwegian zone, and 30,000 t in the Soviet zone. Each of the partners is to license 7,500 t in the "grey zone." The quota of coastal cod has also been changed and fixed at 40,000 t for both nations. As has been the case in 1978, the Soviet Union will be able to fish 80,000 t of her cod quota in the Norwegian zone, and in the light of the total quota reduction, it means that a comparatively larger part of the Soviet quota will be fished in this zone than hitherto. In 1979, Norwegian vessels will only be able to fish 30,000 t of the Norwegian quota in the Soviet zone. The commission also decided to forbid capelin fishing between 1 May and 15 August, and there were critical comments from Norwegian fishermen regarding the reduced quotas.

During the negotiations, it was reported that the Soviet research scientists had suggested a lower catch quantity of Norwegian-Arctic cod for 1979 than the Norwegians, who had based their recommendation on a more long-term alternative. These negotiations originate as a consequence of the serious situation facing fish stocks in the north, and the representatives from both delegations demonstrated the good will and concern that the incidence of spawning, so drastically reduced in recent years, should be restored, Norinform said.

Canada's Fish Industry Will Switch to Metric

Canada's oldest primary industry—commercial fishing—has finalized plans for converting to the metric (SI) system in line with the general move to metric measurement in Canada. January, 1981, has been set as the target date by which Canada's fishing industry will essentially be conducting its business in metric units. A list of preferred metric sizes will be developed for each category of fishery product, based on an industry-wide consensus. A "hard"[1] conversion will be introduced wherever possible.

Responsible for preparing the metric conversion plan was the Fishing and Fish Products Sector Committee of Metric Commission Canada under the chairmanship of I.H. Langlands, of National Sea Products Ltd., Halifax, N.S.

"The conversion plan is intended to be voluntary and has been devised for use by industry and government as a guide in preparing their own detailed plans," said Langlands. "It is not meant to be an exacting pattern for all, but rather as recommendations to allow the transitioin to take effect in as short a period as possible. The plan will be updated as necessary to reflect changing situations."

Canada's fishing industry involves approximately 62,000 commercial fishermen who operate some 28,000 vessels, ranging from 10-m one-man boats to sophisticated deep-sea trawlers. There are close to 800 fish processing plants, employing some 25,000 persons.

Membership on the Sector Committee includes the Fisheries Council of Canada, representing fisheries trade associations across Canada, federal, provincial and territorial departments responsible for fisheries, and fish marketing corporations. An industry-government group under the chairmanship of André Arseneault, of Pêcheurs Unis de Québec, is preparing an information program to alert fishermen and the industry generally to the metric changes which it is planned to introduce.

[1]"Hard" conversion involves a revision of packaging so that all capacities appear in round metric figures, rather than in the metric equivalents of previously used inch-pound measures. "Soft" conversion is a straight conversion of imperial units to the metric equivalent.

West Germany to Look for More Eels Outside Europe

West Germany, the largest consumer of eel in Europe, will have to look for additional sources of supply outside Europe since eel production in the EEC countries is considered to have reached its capacity, according to a survey last year by the Japan External Trade Organization. West Germany's current consumption of eel is reported to average approximately 6,000 t a year, whereas domestic production has been on the decline in recent years, averaging around 1,000 t a year.

Approximately 85-90 percent of eel is consumed as smoked products in West Germany, and the retail price for premium products would run as high as $8/pound. Since most of the imported eel is used for smoked products, a strict standard of minimum 12 percent fat content is applied to the eel imported into West Germany. Import prices of U.S. eel in 1976 were reportedly around $1.50/pound for fresh eel on the average, and $1.10/pound for frozen eel, whereas those from Denmark and Italy were around $2.00-2.25/pound. West Germany's eel imports in 1977 jumped 13.4 percent over 1976 to 5,165 t. The leading supplier was Denmark with 1,844 tons or 35.7 percent, and the United States supplied 251 tons or 4.85 percent. Major foreign suppliers of eel to West Germany in 1976 and 1977 are shown below. (Source: FFIR 78-12).

Major eel suppliers to West Germany, 1976-77.

Country of origin	Amount (t) 1976	Amount (t) 1977	Country of origin	Amount (t) 1976	Amount (t) 1977
Denmark	2,290	1,844	Sweden	219	312
Canada	428	631	Australia	154	162
Poland	399	522	Italy	121	108
Netherlands	472	411	France	108	82
New Zealand	308	405	Ireland	37	52
U.S.A.	377	251	U. Kingdom	30	35

Note: Unless otherwise credited, material in this section is from either the Foreign Fishery Information Releases (FFIR), compiled by Sunee C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, NMFS, NOAA, Terminal Island, CA 90731, or the International Fishery Releases (IFR) or Language Services Daily (LSD) reports produced by the Office of International Fisheries, NMFS, NOAA, Washington, DC 20235.

Alaska Plans New Salmonid Hatchery Facilities

Alaskan voters gave their salmonid hatchery program a boost last year by approving $26.9 million in fisheries development bonding, the Alaska Department of Fish and Game (DFG) reports. This means that the DFG's Division of Fisheries Rehabilitation, Enhancement and Development (FRED) can proceed with plans to build four salmon and trout hatcheries.

The new hatcheries—at Snettisham near Juneau, Main Bay in Prince William Sound, Ship Creek near Anchorage, and at Kotzebue Sound—will have a combined capacity of 155 million eggs. FRED Division Director Robert Roys said the hatcheries will produce fish for Alaska's burgeoning sport fishing population, and will help maintain the commercial salmon industry at a more constant level.

Planned expansion of the Ship Creek hatchery complex, to be built on the military base at Fort Richardson, is intended primarily to benefit sport fishermen. Along with producing 7 million king and coho salmon smolts annually, the proposed expansion will increase rainbow trout production from 500,000 fingerlings to 2.5 million. Alaska Department of Fish and Game planners estimate that the trout production alone will create the potential for an additional 600,000 recreational man-days of angling yearly.

The Snettisham hatchery will be the largest of the new facilities, with a capacity of 71.5 million chum salmon eggs and 5.4 million king and coho salmon eggs. The Snettisham hatchery site also has an unusual water supply. While most hatcheries are constructed along rivers and streams, this hatchery will be built adjacent to a hydroelectric plant operated by the Alaska Power Administration (APA). Water for the power plant is diverted to the site through a 2-mile tunnel from Long Lake, and the hatchery will use water from plant's tailrace, which has been determined to be suitable for fish culture. With FRED and APA sharing the facilities, each agency will be able to operate at lower cost, according to the DFG.

At Main Bay, a hatchery will be built with an initial capacity of 65 million chum and pink salmon eggs. Pink salmon are to be phased out of production at Main Bay after a broodstock of the more valuable chum salmon has been developed. These fish are intended for the gillnet and seine fisheries of Prince William Sound. The hatchery site is remote, but there is plenty of good water and room for future expansion.

The Kotzebue hatchery was added to the bond request by Alaska's Legislature, and consequently, planning for the facility is still at an early stage. It will be a demonstration project, to determine the potential of fish culture in Arctic regions. FRED planners estimate that the four hatcheries will produce $20 million worth of salmon annually when they achieve full production.

TEXAS BAY OYSTER PRODUCTION DOWN

October 1978 sampling in Galveston Bay, where 75 percent of the Texas' oyster crop is harvested, showed a scarcity of marketable oysters, according to Texas Parks and Wildlife Department marine biologist Bob Hofstetter in Seabrook. The situation reflected poor spats (spawns) in 1975, 1976, and 1977 when there was little reproduction, Hofstetter said.

In one major market area west of the Houston Ship Channel in Galveston Bay, the numbers of market-size oysters was down 85 percent from 1977. In another major harvest area around Redfish Reef, market oysters were down 70 percent, he said. For much of the oyster harvest in the past 3 years, oystermen have relied on the abundant crop produced in 1974, but present indications are that the remainder of these 4-years-old oysters from the 1974 crop took a beating last summer, Hofstetter explained.

"In 1978 oyster drills, stone crabs, and disease organisms which prey on oysters flourished due to high bay salinities, and their predation on the mature oysters was severe," he said. Since high salinities

Waste Heat Boosts Growth of Salmon

Use of waste heat from industry can accelerate the growth of coho salmon, reduce production costs, and make a major contribution to salmon production, University of Washington researchers report. E. L. Brannon of the College of Fisheries at the University in Seattle says that a Washington Sea Grant has been utilizing waste heat to reduce generation time of the hatchery population of coho from 3 years to 2 years.

A total of 240,070 coho smolts were reared in warm water and released to migrate to sea after 6 months instead of the usual 18 months in natural waters or in state hatcheries. Encouraged by results of the Sea Grant study, a local electrical utility has proposed the use of waste heat from nuclear power plants for coho salmon and steelhead trout rearing.

prevailed all along the Texas coast last summer, oyster predation was probably significant in middle and lower coast bays as well, he added.

Klamath River Salmon Run Short of Target

The California Department of Fish and Game (DFG), has announced that preliminary estimates indicate 87,000 adult salmon escaped all Klamath River system fisheries last fall to spawn. This is 28,000 fewer salmon than the 115,000 adult fish set by the DFG as the 1978 fall run spawning escapement goal for the Klamath River.

Test fishing conducted by the department through late August 1978 indicated that the escapement goal might not be reached, and led to closures of Indian commercial net fisheries and total closures of all salmon sport fishing in the river. Indian subsistence fishing above the Highway 101 bridge was allowed to continue.

DGF Director E. C. Fullerton observed that "while the 28,000 spawner shortage does not mean that salmon will disappear from the Klamath, it does mean that fewer fish will return in 1981 and 1982 than would have been the case had the goal been reached.

"Repeated or severe failure to meet the escapement goal could get us into real trouble, and result in long term declines in both fish populations and fishing success," he said.

Fullerton also noted that the 1978 run was below those occurring in 1976 and 1977, and that the decline could be the result of the recent drought. "If that is the case," he said, "there is no reason to expect the run to increase in 1979, because the effects of the drought on that run will be even more pronounced." Most king salmon return to spawn at 3 or 4 years of age.

Before the emergency closures ordered late in August, sport anglers caught an estimated 1,700 adult salmon, and Indian net fisheries below the Highway 101 bridge took 10,000. Indian subsistence fisheries above the bridge were unmeasured, but informed guesses as to the catch there range upward from 15,000 fish.

Fullerton acknowledged that the closures were less than popular, and resulted in severe financial problems for local business as well as disruption of the vacation plans of many hundreds of anglers. However, he explained, "our first resposibility is to the resource, and continued fishing, particularly the intensive and effective gillnetting below the Highway 101 bridge, could have resulted in a first-class disaster for the 1978 salmon run. Under the circumstances, we had no choice, and the closures appear to have been warranted."

Department figures indicate that in addition to the 87,000 adult salmon, the run included 23,000 2-year-old males. These smaller fish, called "jacks" or "grilse," do not contribute to the egg potential of the run and are excluded from the escapement goal.

Texas' Tarpon May Be Coming Back

During routine trammel net sampling in Aransas Bay last year, Texas Parks and Wildlife Department biologists caught their third tarpon of 1978 in the Aransas Bay system. This fish was caught at the mouth of Corpus Christi Bayou leading into Redfish Bay. It was 31 inches long and weighed 13 pounds. Increased catches of tarpon by biologists and increasing reports of catches by sportfishermen along the entire Texas coast indicate the tarpon may well be on its way back from recent low populations, the Department says.

South Carolina Seeks Data on Shrimp Habits

South Carolina Wildlife and Marine Resources Department biologists tagged and released some 2,000 large white shrimp in Charleston Harbor last December in an attempt to evaluate how many shrimp overwinter along the coast and how many migrate south.

"Previous tagging studies indicate that large shrimp at this time of year tend to move offshore and then as far south as Florida," said Charles Farmer of the Department. "Small shrimp, on the other hand, appear to remain in our coastal waters during the winter and constitute the spring roe shrimp crop," he added. Farmer is head of the department's Crustacean Management Section within the Office of Conservation Management and Marketing.

Farmer said that previous tagging studies were conducted during years when shrimp were abundant. Currently, white shrimp movements may be different. "Shrimp migration at this time of year (December) depend largely on winter conditions and temperatures, but there is still a lot we don't know about the movements of these animals," Farmer said.

The shrimp were tagged with a red "spaghetti" tag attached to the tail. A number of tags had quickly been returned by commercial trawlers fishing in the Morris Island and Folly Beach areas. Farmer asked that shrimpers save the entire tagged shrimp not just the tag and notify the department at once of any tagged shrimp in their catch. Biologists hoped to tag another 3,000 shrimp early this spring.

Milk Substitute From Fish Waste?

Biologically extracted fish protein hydrolysate (FPH) shows high promise as a milk replacer, particularly in the area of animal feeds, reports the University of Washington, Seattle. According to George Pigott of the Institute for Food Science and Technology at the University, "It is a high protein source and could prove to be of great value, particularly in the diet of weanling calves."

Several procedures for production of FPH have been suggested in recent years for fish waste, gutted fish, and fish fillets, but in general these products have failed to meet published product standards,

says Pigott. According to these standards, milk replacers should have a fat content of less than 1 percent, an ash content of less than 10 percent, and a protein content greater than 70 percent. Work conducted by Pigott and Per O. Heggelund (presently of the University of Alaska), under Washington Sea Grant funding, has succeeded in producing a final product (in powdered form, as a rule) that complies with these limits. The raw material used in the study was fresh fish waste resulting from filleting English sole.

Commercial production looks promising, the researchers report. In addition to creating new milk substitutes, the project has the added advantage of revealing yet another use for waste fish, thus furthering the ecologically sound concept of total utilization.

SHAD BOOSTS SOUTH CAROLINA'S ECONOMY

The South Carolina shad fishery, a lowcountry tradition in the spring may mean more to the state's economy than previously believed. A South Carolina Wildlife and Marine Resources Department project to assess the extent of the fishery determined that in 1978 at least 287,000 pounds of shad worth $197,000 were landed in the state.

This represents the best annual catch reported since 1928 when shad, once abundant, began to decline due to a variety of causes. These included loss of spawning grounds to dams and pollution, and perhaps because of overfishing. But the increased landings probably reflect better reporting of the catch more than a resurgence in the shad population, the Department points out. According to Glenn Ulrich, head of the Department's Marine Resources Division's Finfish Management Section, shad landings are usually not well reported since many fishermen do not sell their catch through commercial seafood dealers.

"Much of the shad catch is sold to small country stores and other individual outlets," said Ulrich. "It is difficult to get an accurate assessment of the fishery when the fish are sold in so many places." Last spring, however, biologists contacted as many as possible of the state's 600 licensed shad fishermen as well as a variety of small retail outlets. The result of this work, according to Ulrich, represents a much more accurate account of shad landings than those compiled strictly through commercial seafood dealers. The shad fishery assessment project, funded in part by the National Marine Fisheries Service, was extended for another year.

"We're now finding that the shad fishery is extensive enough to warrant additional research on the stocks," Ulrich explained. "We hope that by gaining more knowledge of shad we will be in a better position to manage the fishery while maintaining a viable shad population," he added. Finfish Management Section biologists are continuing to work with cooperating fishermen and retail and wholesale outlets to assess the shad catch. In addition, shad caught commercially are being examined to determine age, size, and sex composition of the stocks.

Commercial Salmon Stamp to Aid California Fish

Beginning 15 April, California's commercial fishermen working aboard vessels which land salmon in California must have a commercial salmon stamp affixed to the commercial license. Stamps, at $15, are available through state Department of Fish and Game (DFG) offices and license agents.

The stamp is required under terms of Assembly Bill 2956, which was sponsored by commercial fishermen's associations and carried by then-Assemblyman Barry Keene. The bill was signed into law last year.

Funds raised by stamp sales will be matched by an equal amount from Fish and Game funds and the total will be used to pay costs of rearing 2 million king salmon to yearling size—about 6 inches long. According to the DFG, the program has the potential to increase ocean salmon landings by 100,000 fish. The estimated value of the additional catch which will be generated by the program could run in excess of $2 million annually, the DFG said. The salmon will be raised in the converted spawning channel at Feather River Hatchery in Oroville. Fish reared to yearling size (10 to the pound) will be those that would otherwise be released from the hatchery as fingerlings (90 to the pound).

Experimental programs rearing salmon for release as yearlings show that the technique significantly increases the ocean catch, the DFG said. Stamp sales for the license year beginning 1 April based on about 5,200 vessels in the fleet and a total of about 7,000 working fishermen, are expected to produce about $100,000, half the projected $200,000 cost of the undertaking. Commercial season was scheduled to open 15 April.

Texas Sets Seatrout Size and Bag Limits

The Texas Parks and Wildlife Commission adopted the first bag, possession and minimum size limits ever imposed on the taking of spotted seatrout by sport fishermen in that state late last year. In a public hearing the commission authorized a daily bag limit of 20, possession limit of 40 and a 12-inch minimum size for spotted seatrout (speckled trout) in all regulatory counties for anyone other than the holder of a commercial fishing license.

Commercial fishermen are not restricted to the bag and possession limits, but already were subject to a 12-inch minimum length limit. The new sport fishing regulation went into effect 1 December 1978.

In approving the staff recommendation, commissioners received assurance that the new regulation would be included for review in public regulatory hearings to be held statewide in March 1980. In the meantime, biological surveys will be made to determine the effects of the limits on the resource.

NMFS Scientific Reports Published

NOAA Technical Report NMFS Circular 413. Cressey, Roger F. **"Marine flora and fauna of the northeastern United States. Crustacea: Branchiura."** May 1978. 10 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

ABSTRACT

Eleven species of *Argulus* are known from the northeastern United States. An illustrated key and an annotated list of these species with notes on their hosts and distribution within and without the study area are included. New host records are included.

NOAA Technical Report NMFS SSRF-724. Sutherland, Doyle F. **"Estimated average daily instantaneous numbers of recreational and commercial fishermen and boaters in the St. Andrew Bay system, Florida, and adjacent coastal waters, 1973."** May 1978. 23 p.

ABSTRACT

In the St. Andrew Bay system and adjacent coastal waters, 92.0 percent of the estimated recreational fishing effort was for finfish, 3.7 percent for crabs, 2.7 percent for scallops, 1.4 percent for oysters, and 0.2 percent for shrimp. Coastal waters were the most used area for finfish fishing (36.2 percent), followed by St. Andrew Bay (31.8 percent), North and West Bays (21.6 percent), and East Bay (10.4 percent). Of the estimated effort, 43.5 percent was from fixed platforms extending over water, 30.8 percent from private boats, and the remaining 25.7 percent from shoreline platforms, charter boats, and water. The most popular method of finfish fishing was with a rod and reel (93.9 percent).

The annual number of daytime anglers was estimated to range from 208,400 to 303,200 with associated expenditures ranging from \$4.2 to \$6.1 million. The estimates are based on the number of anglers actually seen fishing. The number of transit anglers and other recreational fishermen probably equal or exceed the basic estimates. The average daily instantaneous number of occupants of transit motorboats alone was estimated to reach 52 in North and West Bays, 32 in East Bay, 392 in St. Andrew Bay, and 207 in coastal waters.

The distribution of commercial fishing effort among fisheries was estimated to be 34.7 percent for shrimp, 33.3 percent for oysters, 22.0 percent for finfish, 8.9 percent for scallops, and 1.1 percent for crabs. The principal area for each fishery was: East Bay for shrimp (36.5 percent), oysters (85.7 percent), and crabs (85.2 percent); coastal waters for finfish (44.1 percent); and St. Andrew Bay for scallops (84.4 percent). The highest estimated average daily instantaneous number of active and transit commercial fishermen in each fishery was 66 for shrimp, 37 for oysters, 91 for finfish, 19 for scallops, and 7 for crabs.

NOAA Technical Report NMFS Circular 412. Manooch, Charles S., III, and William W. Hassler. **"Synopsis of biological data on the red porgy, *Pagrus pagrus* (Linnaeus)."** May 1978. 19 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

ABSTRACT

A synopsis of the biology of the red porgy, *Pagrus pagrus*, that includes taxonomy, morphology, distribution, aspects of the life history, behavior, and abundance. Also included are: Discussions of commercial and recreational fishing methods and fishing grounds, and size, age, and sex composition of the recreational catch off North Carolina and South Carolina and commercial catch off Argentina.

NOAA Technical Report NMFS Circular 410. Malone, Thomas C. **"The 1976 *Ceratium tripos* bloom in the New York Bight: Causes and consequences."** May 1978. 14 p.

ABSTRACT

An extensive bloom of the dinoflagellate *Ceratium tripos* occured throughout the New York Bight between January and July 1976. Population size peaked during April-June and declined rapidly during July. A floc consisting primarily of decaying *C. tripos* cells was observed to cover the bottom during July between Sandy Hook and Atlantic City between 5 and 50 km offshore. The distribution of the floc roughly coincided both temporally and spatially with the development of a subthermocline oxygen minimum layer and extensive fish kills.

Prior to the onset of thermal stratification (January-March), the *C. tripos* population was uniformly distributed throughout the water column and was growing photosynthetically. As the water column began to stratify in April, the population aggregated in a layer 1-3 m thick near the base of the thermocline between the 0.1 and 10 percent light depths. If photosynthetic growth was occurring during May-June, it was at a very low rate (about 0.02 g C/m^2d^{-1} at the 1 percent light level). The possibility of no growth or heterotrophic growth cannot be dismissed, especially in the apex of the New York Bight and along the New Jersey coast.

The *C. tripos* bloom resulted in a gradual accumulation of a large quantity of particulate organic matter which did not enter pelagic food chains. Respiration of this biomass and its decay below the thermocline were probably major factors in the development of oxygen-poor bottom waters in June and July. Localization of the oxygen minimum layer off the New Jersey coast probably reflects the bottom topography of the New York Bight and the distribution of the *C. tripos* biomass within the Bight.

The occurence of *C. tripos* blooms per se is not unusual. The bloom was unique only in terms of the size of the population produced, its areal extent, and its duration. Because high densities of *C. tripos* developed throughout the New

York Bight during January-March with maximum densities between midshelf and the shelf break, it is unlikely that the bloom occurred in response to local nutrient enrichment (related to the disposal of domestic and industrial wastes) during the period of the bloom. However, causes of the bloom and its collapse cannot be determined, based on existing information.

Underwater Diving Fatality, Fishing Vessel Casualty Data Given

A study of fishing vessel mishaps is provided in **"A Safety Analysis of Fishing Vessel Casualties."** This is a report prepared by William J. Ecker of the U.S. Coast Guard, Transportation Department, Washington, DC 20590, for the 66th National Safety Congress and Exposition last October.

Documented fishing vessels have grown about 50 percent in the last 12 years, says the author, citing NMFS statistics. The number of fishing vessels involved in marine casualties has increased correspondingly in the same time span, he adds. The paper examines some of the more frequent types of marine casualties involving fishing vessels and highlights salient aspects of the casualties by circumstance, location, fishing fleet type, and the subsequent result of the casualties (ie., loss of vessel, loss of life, or both).

The report briefly profiles the U.S. fishing fleet and analyzes the casualties reported to the U.S. Coast Guard during the 1972-77 fiscal year period. Finally, the report presents some conclusions on fishing vessel mishaps and draws attention to areas for possible further study.

During the 6-year period, over 4,800 fishing vessels were reportedly involved in a vessel casualty, with almost 89 percent consisting of five general types: 1) Groundings, 2) material failures, 3) operational collisions, 4) flooding-foundering-capsizing, and 5) explosions-fires. Each of the general types of casualties are discussed in separate sections. According to the report, the most notable increases appear in the categories of groundings and flooding-foundering-capsizing.

The report also presents the selected casualty types in terms of the seriousness of the consequences of each type relative to personnel deaths and vessels lost. An index of seriousness in the form of a ranking compares casualty types against one another. The highest overall rankings were jointly attained by flooding-foundering-capsizing and by groundings, with the former category being first in the number of deaths and number of vessels lost. The latter was ranked first, second, and third in casualty frequency, vessels lost, and deaths, respectively. The author points out that flooding-foundering-capsizing produced almost four times the number of fisherman deaths as the next closest casualty type.

The category flooding-foundering-capsizing produced the largest death and vessel-lost ratio per incident, the report notes, primarily from founderings. The dollar damages accruing from this casualty grouping were the highest of all casualty types compared and the author recommends further analysis and research into the specifics of these incidents, owing to their serious consequences.

Four appendices give tabular data on : 1) Environmental factors present during each casualty type, 2) characteristics of fishing vessels involved in each casualty type, 3) comparison of selected geographic locations for each casualty type, and 4) casualty results for each casualty type.

Deaths of nonprofessional scuba divers increased slightly in the United States, from 131 in 1975 to 147 in 1976—the latest year for which figures are available—according to a report, **"U.S. Underwater Diving Fatality Statistics 1976,"** released in January by the National Oceanic and Atmospheric Administration.

"With an estimated 2.5 million active scuba divers in the Nation, the number of fatalities is very small," said David H. Peterson, Assistant NOAA Diving Coordinator. "Scuba diving continues to be a safe and enjoyable sport."

Deaths jumped sharply in Hawaii and continued high in Florida in 1976, the report notes. Increasing use of warmwater recreational areas by casual diving visitors account for the relatively high level of fatalities in those states and in California, according to the Commerce Department official. Florida continued to have the nation's highest toll, 40, while fatalities in Hawaii increased from 6 in 1975 to 11 in 1976.

Second highest death toll was recorded by California with 23 deaths, up from the 17 recorded in 1976 but still well below the 36 and 32 set in 1974 and 1975 respectively. California has conducted an intensive scuba safety program in recent years to reduce the number of deaths, NOAA officials said.

"Analysis of the figures shows that in many cases the divers who died ignored the teachings of their scuba instructors or took chances in unfamiliar situations," Peterson said. "The overwhelming majority of divers carefully adhere to good diving practices, and dive safely."

The report shows that scuba diving deaths are not confined to the coasts and Great Lakes states, but also occur in inland lakes, rivers, quarries, and mine shafts. Cave diving is among the most dangerous, the report notes. The National Underwater Accident Data Center (NUADC) at the University of Rhode Island, which compiled the report, recorded seven instances in 1976 where two people died in cave diving accidents, six double deaths in Florida and one in New Mexico. "NUADC has not been able to establish the number of people engaged in cave diving..." the report says, "but there is no question in the author's opinion that cave diving is the most dangerous of all sport diving activities."

The report dismisses equipment failure as a cause of fatal accidents. For example, it says that in 1976 "no fatality could be directly assigned to a properly maintained regulator as the primary cause."

The report, "U.S. Underwater Diving Fatality Statistics, 1976," was prepared by NUADC for the Manned Undersea Science and Technology program, Office of Research and Development, NOAA, and the Underwater Safety Project of the U.S. Coast Guard's Office of Merchant Marine Safety, Department of Transportation. Single copies are available at no cost from either of the two agencies.

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 6, "A List of Common and Scientific Names of Fishes from the United States and Canada," third edition, 1970. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

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Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

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Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8- × 10- inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 1107 N.E. 45th Street, Room 450, Seattle, WA 98105.

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